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AUGUST 1961

JOURNAL

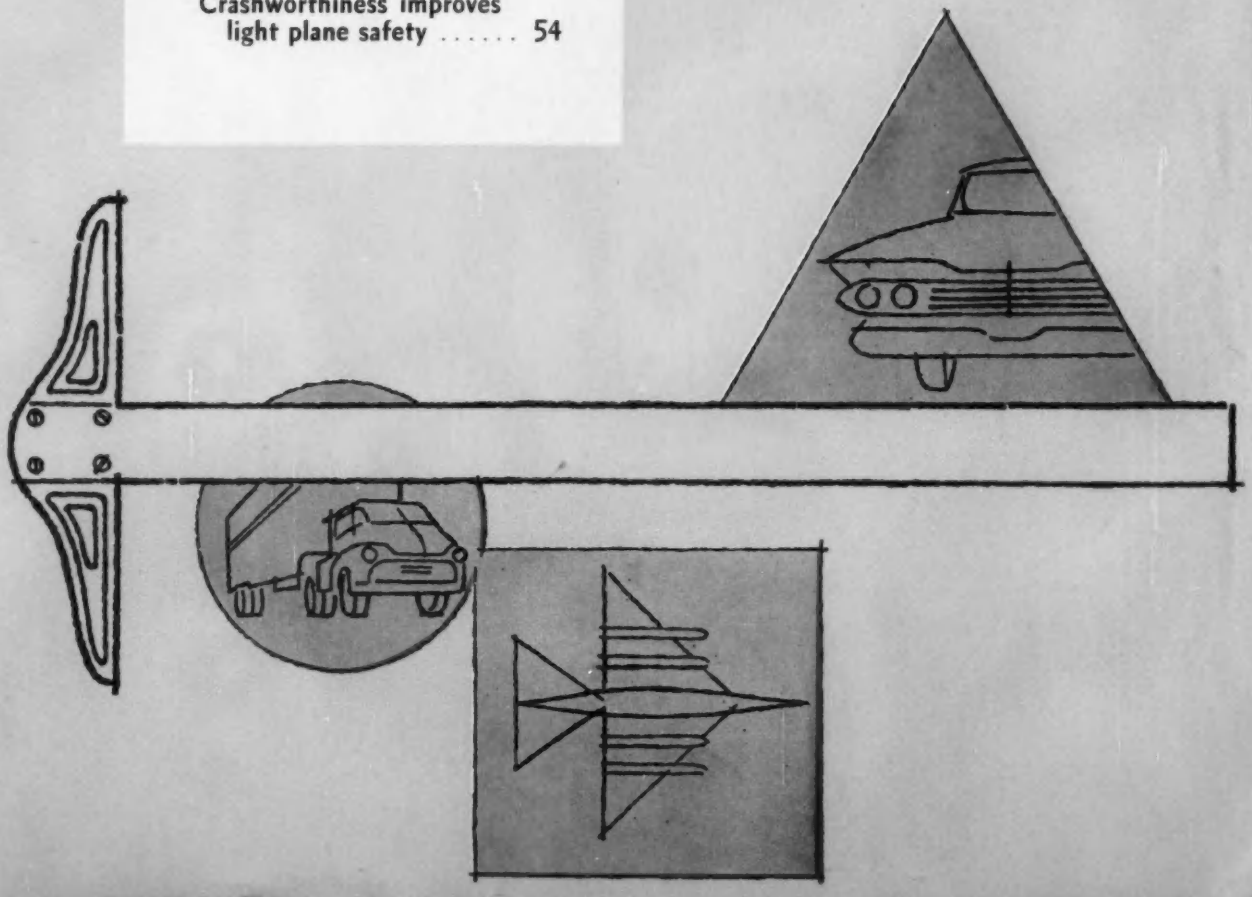
Piston-ring and cylinder-bore wear 33

Reduce distortion from grinding, milling 41

Piezoelectric ignition for small engines 46

Computers can be the slaves of management 51

Crashworthiness improves light plane safety 54



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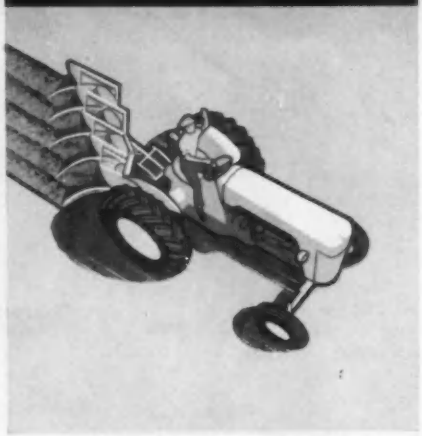

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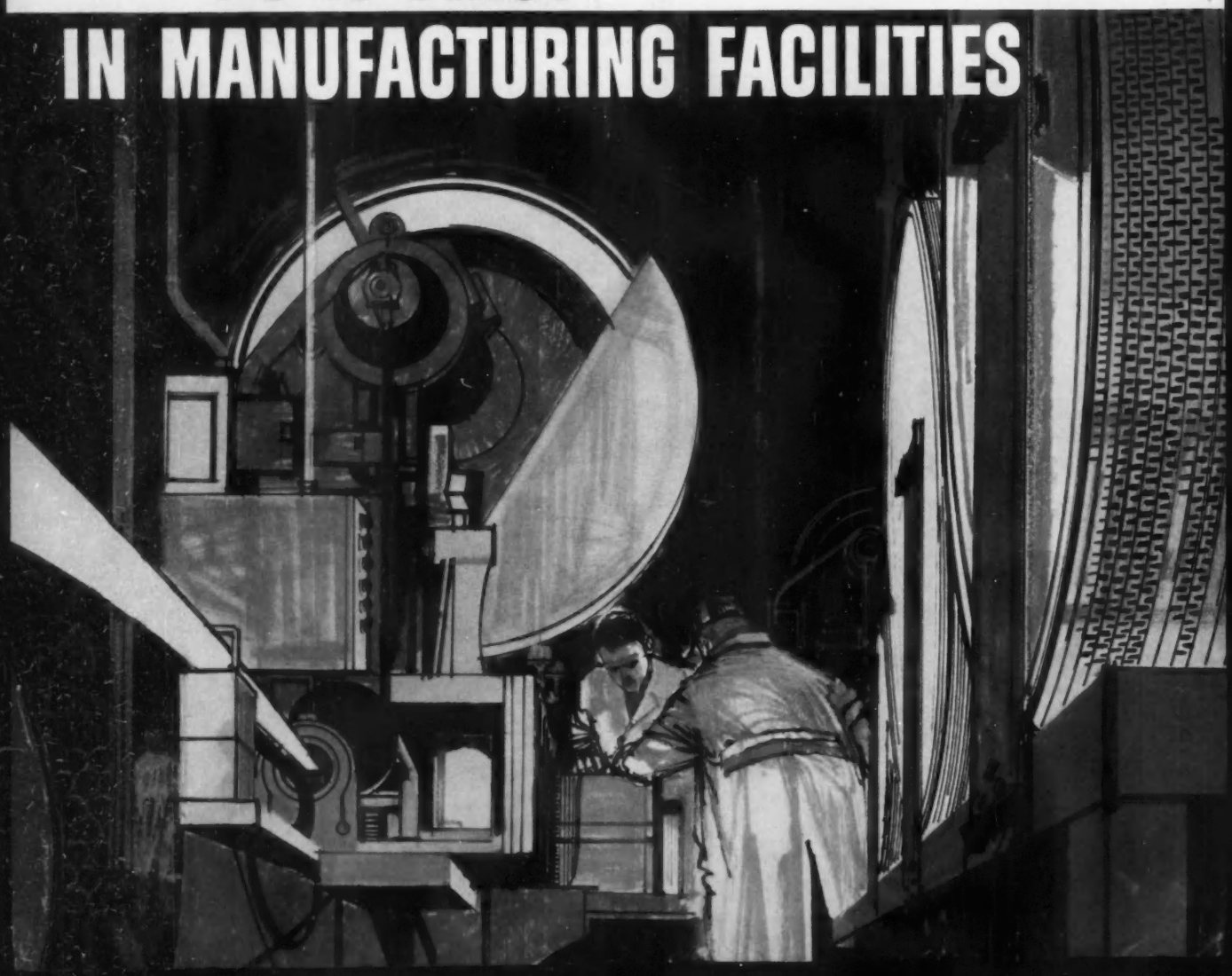

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Contents • August, 1961

INDEX of 1961 SAE Journal technical articles will appear in the December 1961 issue

Chips . . . from SAE meetings, members, and committees 31

Piston-ring and cylinder-bore wear 33

Free discussion between SAE members at Engine Workshop session unveils current engine wear problems. Causes . . . Solutions . . . illuminate session planned by Subcommittee on Engines, SAE Passenger Car Activity. — **W. S. James**

Reduce distortion from grinding, milling 41

Flight vehicles are using more high strength steels with extremely thin cross sections. So, distortion of the workpiece is very important in maintaining close tolerances. (Paper No. 340L) — **L. J. Nowikowski, John Maranchik, Jr., and Michael Field**

Piezoelectric ignition for small engines 46

Easier starting and ability to fire badly fouled plugs are chief advantages claimed for new system. (Paper No. 375A) — **Edwin Crankshaw and R. Arnold**

Computers can be the slaves of management 51

Management must continue to use judgment, policy decisions, and experience to run its business . . . but computers can be management's slaves, providing quickly, factual, unbiased answers to questions that management poses. — **L. (Bud) Tellander**

Crashworthiness improves light plane safety 54

With proper design, it would not require a "miracle" to be able to walk away from a crash. (Paper No. 365A) — **Karl H. Bergey**

Wolfwagon — something new in truck design 56

The Wolfwagon truck is designed to be operated singly, in pairs, or in trains of three or four units, with one driver and all engines running. (Paper No. 358A) — **L. J. Wolf**

Design for safety in fast hydrofoil ships 58

Foils and struts present perhaps the most novel design problem in development of structural design for safety in high-speed hydrofoil ships. (Paper No. 355B) — **Richard G. Merritt**

Better exhaust system boosts engine output 60

Improved scavenging and charging, which combine to give better performance, can be attained for 2-stroke engines through proper tuning of the exhaust system. Tests performed on a UD3 2-cycle diesel engine, recently, showed a 15% difference in output between the most favorable and unfavorable pulsation conditions. (Paper No. 367B) — **Ichiro Watanabe, Tetsuro Nakada and Toru Ando**

Beech developing twin turboprop 62

High performance, simple operation sought for personal-type airplane now under test. (Paper No. 365C) — **M. J. Gordon**

To order papers on which articles are based, see p. 6.

Continued on page 2

Contents • August, 1961 • Continued

Metals and plastics compared 64

More and more specifications for both metals and plastics are being written as performance specifications. The designer's major concern today is to find and apply a material or materials with the right combination of engineering properties to meet a particular set of design and service conditions. (Paper No. 381B) — **M. W. Riley and Donald Peckner**

What to expect of production engineers 68

Immediate answers; complete understanding; thorough consideration; and accurate factual information are what product engineers expect of production engineers. — **G. R. Fitzgerald**

The "glue line" comes to automotive production 70

The "glue line" is finding its place in automotive production. That thin film of adhesive between two parts which are bonded together is forging ahead slowly but surely in the automobile as well as the aerospace industry. (Paper No. 330A) — **Irvin E. Poston, Kenneth D. Downing, and Kenneth J. Mack**

Thermionic converters for space vehicles 72

Described here is the use of the vacuum diode for a low orbit satellite mission and a vapor diode for a Mars space probe mission. (Paper No. 350C) — **R. E. Henderson and D. L. Dresser**

3 ways to speed metal removal 78

Stock removal of high-temperature alloys can be speeded up by: gun drilling, hot machining, and plasma arc cutting. — **R. N. Ciccarelli**

M.I.T. develops engine for friction, wear studies 80

M.I.T.'s Sloan Automotive Laboratories have designed a special engine cylinder to measure the instantaneous friction of piston rings in a firing engine. (Paper No. 379F) — **A. R. Rogowski**

Trisonic transports need better metals 84

Alloy types having potential application as sheet materials for trisonic transports include the titanium alloys, the precipitation-hardening stainless steels, the metastable austenitic stainless steels and the super alloys. These metals are all candidates for the job that aluminum has long been doing in airplane wings and fuselages. (Paper No. 341D) — **W. F. Brown, Jr., G. B. Espey, and M. H. Jones**

Plastics are O.K. for instrument cluster 88

Vibration, heat, and cold tests prove to Buick engineers feasibility of plastics for an instrument cluster. — **Henry C. Stuerzl**

New 3-member hydrodynamic drive unit 91

A three-member hydrodynamic drive unit — has some characteristics of both a fluid coupling and a torque converter. (Paper No. 359B) — **J. W. Qualman and E. L. Egbert**

H-bands for carbon steels bow in 94

Just approved are hardenability bands for SAE 1041 and 1045. These two bands are the beginning of a carbon steel H-band series paralleling the alloy steel H-bands. (TR-199) — **George Manning**

More on page 1

To order papers on which articles are based, see p. 6.

Briefs 5

Radiation in space hampers thermal control (Paper No. 339C) 96

Signal sensors snag nuclear ram jet controls (Paper No. 338D) 96

Torque curve of Olds F85 engine determined by computer 96

Rocket nozzles don't get as hot when internal ablation is used (Paper No. 354B) 97

Production techniques can lead to product corrosion and fatigue failures 98

Keep competitive! Question machine value (Paper No. 334A) 98

Automatic checkout system tests missiles (Paper No. 331D) 98

Mission success criteria for design of spacecraft (Paper No. 343B) 100

Propulsion systems for undersea vehicles (Paper No. 349C) 100

How Martin Co. handles weapon projects (Paper No. 342C) 100

Product reliability depends on many factors 101

Higher compression ratio engines stalled (Paper No. S290) 101

Engineering — production seek good communications 101

Fuel anti-icing additives forward flight safety step (Paper No. 356B) 102

Gun drills cut super alloys (Paper No. 340K) 102

Ceramics potentials for radiative-type heat shields (Paper No. 354C) 102

Editorial 29

News ..... (Contents) 103

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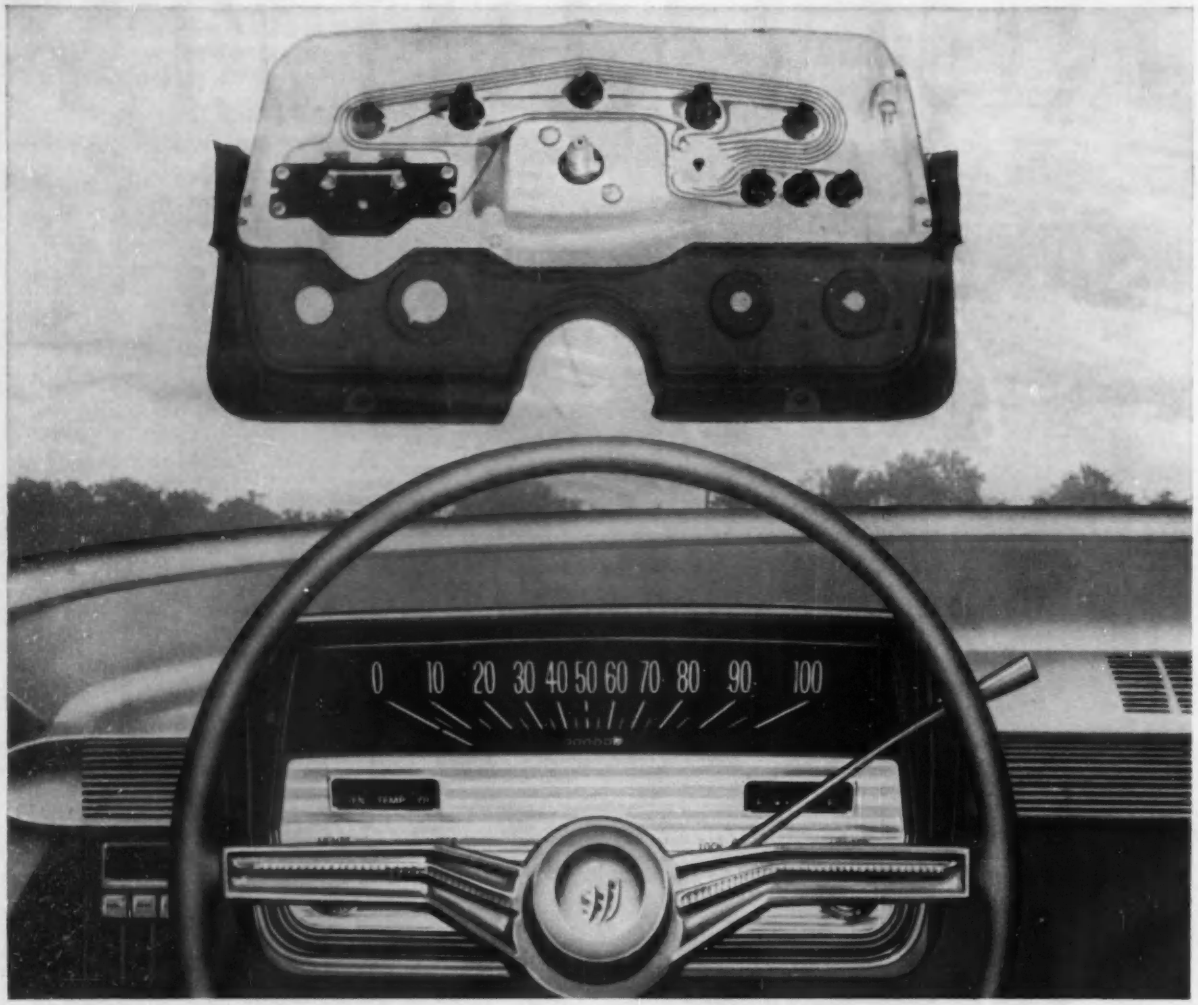

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AEROSPACECRAFT

Factors Involved in Selection of VTOL Transport Configuration, R. E. KUHN, M. O. McKINNEY. Paper No. 337D. Configuration types include those that use rotor for lift and propulsion in cruising flight, those that fly as airplane using wing lift and separate propulsion in cruising flight, and combination configurations; hovering considerations; STOL performance, and powerplant reliability; helicopter best for VTOL missions of short range; where mission is one of transportation and VTOL is required, adherence to design rules for good cruise performance must be followed.

Advantages of Medium Thrust Nuclear-Electric Rocket, R. W. HALIET, Jr., S. GRONICH. Paper No. 338A. Energy requirements for 3-man orbit-to-orbit Earth-Mars round trip mission; capabilities of high thrust and micro-thrust systems for accomplishing mission; medium thrust nuclear electric rocket satisfying mission requirements; basic concept of thermionic nuclear magnetogasdynamic system (TIN-MGD); vehicle configuration; nuclear and solar flare shielding; analysis shows that medium thrust vehicle could complete Earth-Mars round trip in 1 yr with payload fraction of 0.345.

Minimum-Volume Gas-Cooled Nuclear Heat Exchangers, C. D. FULTON, W. B. THOMSON. Paper No. 338B. How volume of fuel elements in gas cooled reactor can be minimized; heat exchangers of straight gas passages through solid materials and of rod matrix, consisting of round rods stacked in crisscross array are studied; heat transfer and friction coefficients; elimination of heat transfer coefficient; how compactness can be achieved by subdividing reactor core into many pieces; potential of method.

Nuclear Engine Operating Considertions, G. W. NEWTON. Paper No. 338C. Comparison of aircraft nuclear propulsion with conventional propulsion, based on results expected from research programs; operating factors affecting initial subsonic applications and their growth discussed with respect to feasibility and economy; 1967–1970 time period is assumed for operational aircraft; typical subsonic craft used as example; basic operating problems in areas of flight, airport requirements, ground handling, and maintenance.

Transient Effects of Nuclear Radiation on Electronic Equipment, J. W. CLARK, T. D. HANSCOME. Paper No. 339A. Study at Hughes Aircraft Co. of system vulnerability exposing operating equipment in laboratory simulating features of weapon environment; threshold radiation levels for malfunctions in subsystems and modules evaluated for effects on performance in nuclear weapon detonation environment; prediction of system response; transient effects can lead to malfunctions at rates as low as 10^5 to 10^6 r/sec; systems can be made to withstand 10^7 to 10^8 r/sec.

Determination of Effects of Satellite Environment on Thermal Radiation Characteristics of Surfaces, R. E. GAUMER. Paper No. 339C. There may be different materials external on satellite and exposed to various environment phenomena; any temporal change in characteristics of exposed materials will alter equilibrium temperature of components; efforts to solve resultant problems; necessity for thermal control; thermal control materials; nature of satellite environment; interactions between materials and environmental phenomena.

Supersonic Transport: Pilot Views on Operational Goals, Handling Characteristics, and Related Subjects, W. W. MOSS, J. R. GANNETT, P. H. PATTEN. Paper No. 341B. Problem areas where attention to piloting aspects is of vital importance involve two regimes of flight; airplane handling characteristics are studied with respect to lateral directional characteristics, rudder and longitudinal control requirements, and approach configuration speed stability; landing performance, considered with respect to approach speeds, and landing distance; pilot handling requirements.

Passenger Density and Accommodations as Factors in Supersonic Transport Design, P. SHIPPS, J. FRICK. Paper No. 341C. Engineering and eco-

continued on page 6

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7	27	143	165
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10	126	146	168
11	127	147	169
12	128	148	170
13	129	149	171
14	130	150	173
15	131	151	174
16	132	152	175 top left
17	133	153	175 top right
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19	135	156	178
20	136	157	Inside front cover
21	137	158 top left	Inside back cover
22	138	160	Outside back cover
23	139	161	
24	140	162	

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continued from page 5

nomic reasons for making changes in passenger provisions; increasing importance of vehicle size and shape should influence compromise of efficiency vs passenger spaciousness; comparative supersonic transport characteristics; relationship between passenger density and direct operating costs; various higher density arrangements and savings in operating costs.

Considerations in Selection of Wing and Fuselage Sheet Materials for Trisonic Transports, W. F. BROWN, Jr., G. B. ESPEY, M. H. JONES. Paper No. 341D. Study of tensile properties to evaluate strength potential available in titanium alloys, precipitation hardening, and cold worked metastable austenitic stainless steels, and super alloys; unstable crack propagation resistance under static loading; stability under long time load and temperature; nonsteady load and temperature; it is possible to define alloys and assess important variables in design of Mach 3 aircraft. 39 refs.

Consideration of Powerplants for Supersonic Transport Aircraft, W. H. SENS, T. G. SLAIBY. Paper No. 341E. Selection of type best suited depends on engine characteristics such as specific fuel consumption at sub- and supersonic cruise, acceleration thrust, weight, initial price, maintenance costs, and take-off and landing noise; weight and performance characteristics of turbojet, turbofan, and 2 types of turboramjet; how significant engine design variables influence overall powerplant characteristics; cost factors; overall powerplant comparison.

Supersonic Transport — Required Characteristics of Configurations, M. R. NICHOLS. Paper No. 341F. Overall configuration requirements which represent view of group conducting research at NASA Langley Research Center; problem areas of takeoff noise, sonic boom, airframe and engine life; examination of cruise performance, stability, materials and structures, aeroelastic considerations, and engine configurations; advances in performance capability and operational flexibility can be achieved through incorporation of variable wing sweep and advanced fan type engine.

Contributions of Dyna-Soar to Space Flight Technology, Y. A. YOLER. Paper No. 344A. Features of Dyna-Soar which is piloted, hypersonic aircraft or vehicle with capability to reside in orbit for short periods of time; manned missions, hypersonic and space flight can become routine undertaking to permit full exploration of their scientific potential i.e., in combination of following factors: economic boost of large payloads, efficient and safe recovery, existence and protection in space, and suitable subsystems for space missions; outline of unique capabilities.

Thermal Environment of Interplanetary Space, J. C. BALLINGER, J. C. ELIZALDE, E. H. CHRISTENSEN. Paper No. 344B. Space thermal environment is broken down into direct solar radiation, planetary thermal radiation, and planetary albedo; results of study of this environment; studies made in parametric manner using direct analytical solutions where possible, and numerical techniques; values obtained for integration step by step over trajectory of mission considered.

Inflatable Balloon-Type Deceleration and Stabilization System for Recovery of Space Vehicles, F. R. NEBIKER. Paper No. 344C. To solve problems of decelerating and stabilizing recovery vehicles, other form of positive stabilization and deceleration means is required than conventional parachute; methods used by Goodyear Aircraft Corp. to establish feasible system with extended performance capabilities; research and test techniques; it is shown that expandable structure, balloon-type deceleration and stabilization system is feasible.

Maintenance, Repair and Assembly in Space by Remote Means, J. W. CLARK. Paper No. 344D. Concept of space Mobot system for assembly, maintenance, and repair of orbiting objects, based on Hughes Mark II Mobot vehicle designed for use in nuclear laboratories; requirements of remote handling system incorporating handling

continued on page 129

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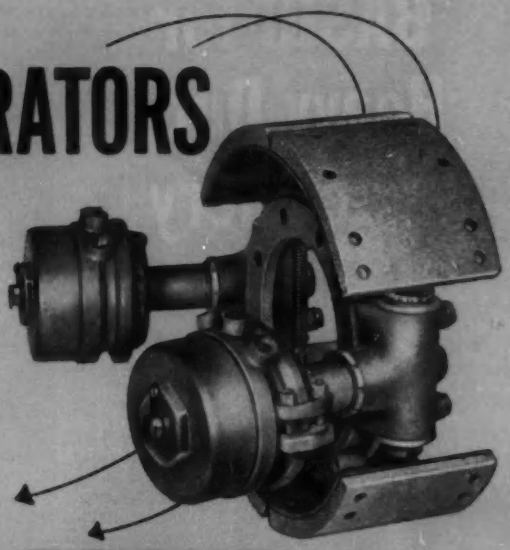

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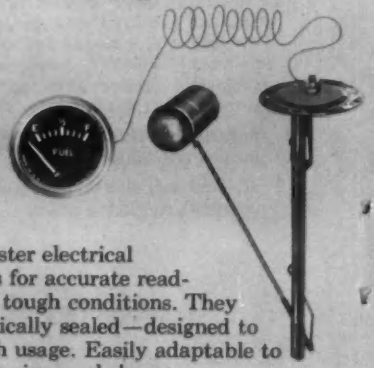

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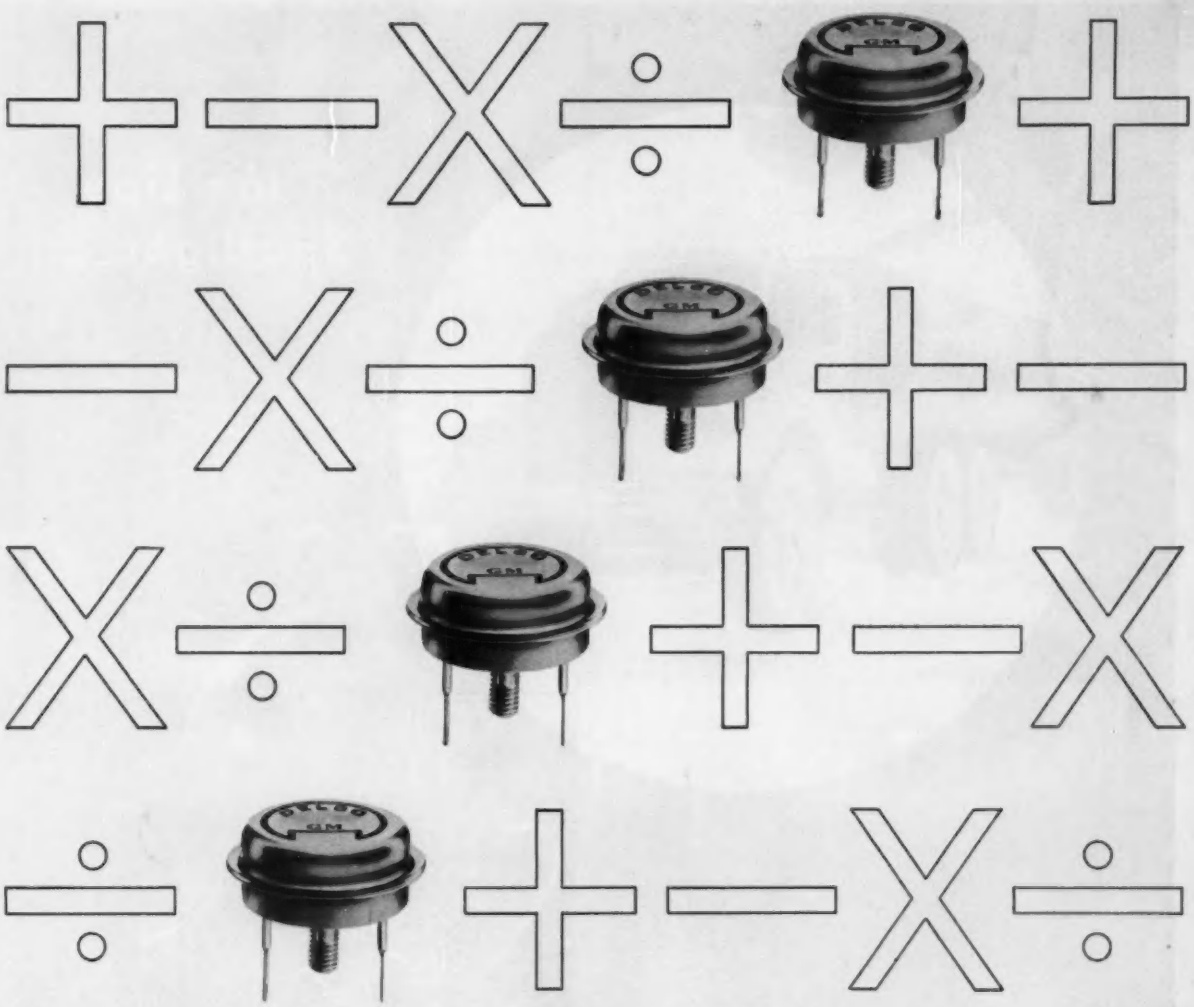

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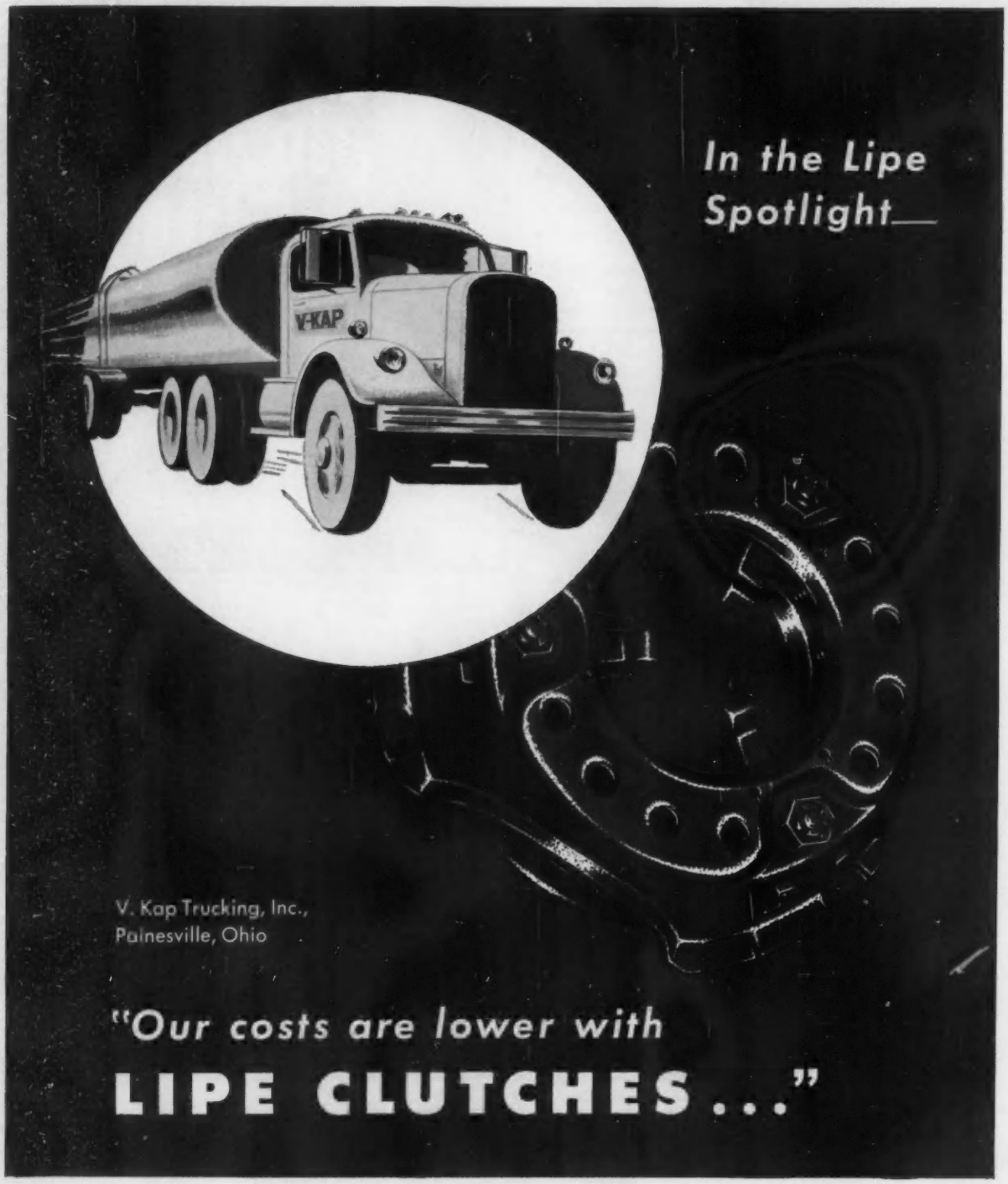


"Rolling a quarter-million payload miles a month really puts the pressure on our 54 tractors," reports Raymond Luhta, service manager for V-Kap Trucking, Inc., Painesville, Ohio.

"A performance check showed us that units with Lipe clutches were logging about 150,000 miles per clutch. Now our entire fleet (Whites, Fords and Internationals) is equipped with Lipe Clutches, either as original equipment or on a continuing replacement basis.

"As a result, our tractors are spending more time on the road and less in the shop."

Reasons like these – better mileage, more capital equipment use and lower maintenance cost – reveal why so many fleets are converting to Lipe Heavy-Duty Clutches. Make performance prove to you, too, that...

LIPE DELIVERS IN THE CLUTCH

© LIPE—ROLLWAY CORPORATION, SYRACUSE, NEW YORK

What synthetic sealing materials should I use—and when

Environmental conditions generally dictate the type of synthetic rubber for a specific oil sealing application.

Where temperature, shaft speed, runout, eccentricity, and lubricant type are "normal", standard Buna N synthetic rubber compounds are satisfactory. If, however, the application is "dry running", a compound must be selected that will operate satisfactorily with a very small amount of lubricant. If the application involves excessive abrasion, highly "loaded" compound stocks should be provided. At temperatures over 250° F polyacrylics or silicone compounds are indicated; if high temperature is accompanied by a solvent base or additive lubricant, polyacrylics are definitely preferred.

Thus many variables govern successful oil sealing. The chart below gives more data; for complete information from the world's foremost oil seal laboratories, call your National Seal engineer. He's in the Yellow Pages, under Oil Seals or O-Rings.

SYNTHETIC RUBBER COMPOUNDS | **RECOMMENDED APPLICATIONS**

Comp. No.	Base Polymer	Min/Max Operating Temperature	Life Index	Price Index	Automatic Transmissions	Pinions	Axle Seals	Engine Seals	Misc. Applications
B-63	Buna N	—40°F/225°F	100	100				Excellent for small gas engines.	Excellent for small non-spring loaded seals.
B-86	Buna N	—30°F/225°F	100	100		Satisfactory for medium temperature applications.	Truck and automotive rear axles. General use.	Satisfactory as general purpose material where temperature permits.	General purpose Buna N applications.
B-94	Buna N	—60°F/250°F	100	100					Excellent against aromatics and some military aircraft oils, fuels.
B-95	Buna N	—30°F/225°F	100	100					Good dry running compounds for applications requiring high durometer stock.
C-6	Buna N	—30°F/225°F	100	100			Excellent for semi-rough axles. Has good wear qualities.		Good for pressure seals due to high durometer and clean trimming.
L-28	Acrylon BA-12	—30°F/300°F	400	125	Good for temperature range indicated.	Satisfactory in single lip construction.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general applications. Can be used with EP or GL-4 oils.
L-34	Hycar PA-21	0°F/300°F	400	115	Good for temperature range indicated.	Dual lip limited contact for high temperatures.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general single or dual lips. Ok with EP or GL-4 oils.
S-48	Silicone*	—80°F/400°F	1500	150	Excellent high and low temperature life.	Silicone Compounds Not Recommended With EP Lubricants at high temperatures.		Excellent for general engine use. Suggested for premium gasoline and Diesel engines.	Excellent wide range material. Avoid use in EP and GL-4 oils.
S-49	Silicone*	—80°F/300°F	600	130	Good at high and low temperatures.			Very good for general engine use; premium gasoline and Diesel engines.	Very good wide range material. Avoid use in EP and GL-4 oils.

*Silicones require special stabilization for satisfactory use in aromatic oils at high temperatures.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, California

Another first from Delco-Remy!

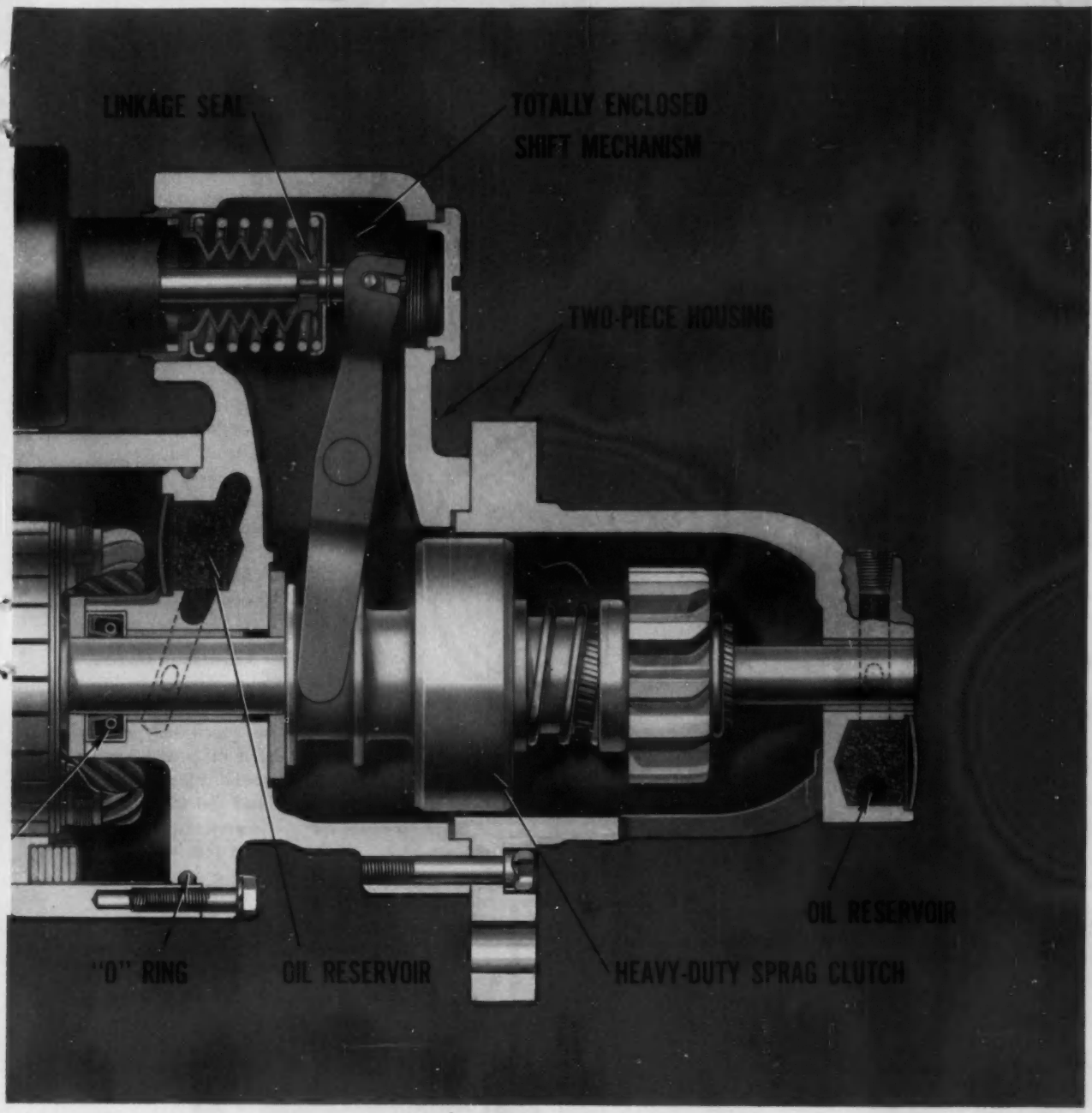
NEW DELCO-REMY HIGH-OUTPUT MOTOR

Completely new series of high-output cranking motors! These 12-volt motors have the torque and speed to do the same job as 24-volt motors of equal size *and on the same battery power.* No need for series-parallel switches and their complicated wiring on engines up to 900 cubic inches. These solenoid-operated, over-running clutch type heavy-duty cranking motors come with special two-piece drive housings that permit 24 different motor mounting positions. Their new 50% longer brushes, together with sealing rings (optional) and large oil reservoirs (optional), assure extra-long operating time between overhauls.

TOTALLY ENCLOSED DRIVE SHIFTING MECHANISM is protected against dirt, water, slush and ice. This enclosure, plus the shaft seal and linkage seal, also blocks transmission oil leakage into the motor and solenoid.

TWO-PIECE DRIVE HOUSING DESIGN permits 24 different solenoid positions which allows greater standardization—cuts fleet inventories. Nose housings are available in S.A.E. #2 and #3 mountings.

HEAVY-DUTY SOLENOID AND SWITCH provide positive pinion engagement and safely handle maximum starting current. Special seals keep out foreign material and allow increased contact life.



ELIMINATES SERIES-PARALLEL SWITCHES

SPRAG CLUTCH DRIVE operates with non-chamfered ring gear. Pinion indexes on spiral spline, positively engaging ring gear before power is switched on. Engagement of the pinion and ring gear is maintained during intermittent or sporadic engine firing.

HEAVY BRUSH INSPECTION PLATES resist damage from use and handling—are sealed to prevent leakage.

Engine manufacturers are invited to write directly to Delco-Remy for complete information and engineering assistance on the specific application of these new motors.

FROM THE HIGHWAY TO THE STARS

Delco-Remy
electrical systems

GM GENERAL MOTORS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, IND.

SPICER INTRODUCES NEW TRANSMISSION!

Extra-Heavy-Duty 8000 Series Direct on 5th

Here is the extra-heavy-duty transmission that truck fleet operators have demanded! The new Spicer 8000 Series 5-speed transmission is the largest capacity direct-on-fifth transmission on the market. It is designed primarily to complement big diesel engines.

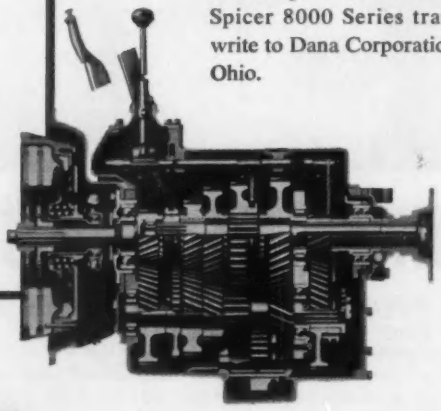
With the new 8000 Series Spicer transmission, top vehicle speed is obtained in direct drive. Ratios of the new transmission are spaced so that they are functionally split or compounded with ratios of 2- and 3-speed axles and 3- and 4-speed auxiliary transmissions. Spicer 14" 2-plate and 15½" 2-plate clutches are matched to work at top efficiency with this new 8000 Series unit.

Ratios in the standard 8052 (iron case) and 8054 (aluminum case) and the optional 8052-A and 8054-A are:

RANGE	STANDARD MODELS 8052 and 8054	OPTIONAL MODELS 8052-A and 8054-A
1st	7.30 to 1	5.68 to 1
2nd	4.54 to 1	3.13 to 1
3rd	2.75 to 1	1.71 to 1
4th	1.65 to 1	1.29 to 1
5th	1.00 to 1 (direct)	1.00 to 1 (direct)
Reverse	7.00 to 1	5.47 to 1

NOTE: The 8031 and 8035 Series Spicer auxiliary transmissions have been augmented by a new underdrive ratio of 1.19 to 1 to better complement the ratios of the new Series 8000 direct-on-fifth transmissions.

For complete information on the new Spicer 8000 Series transmissions, write to Dana Corporation, Toledo 1, Ohio.

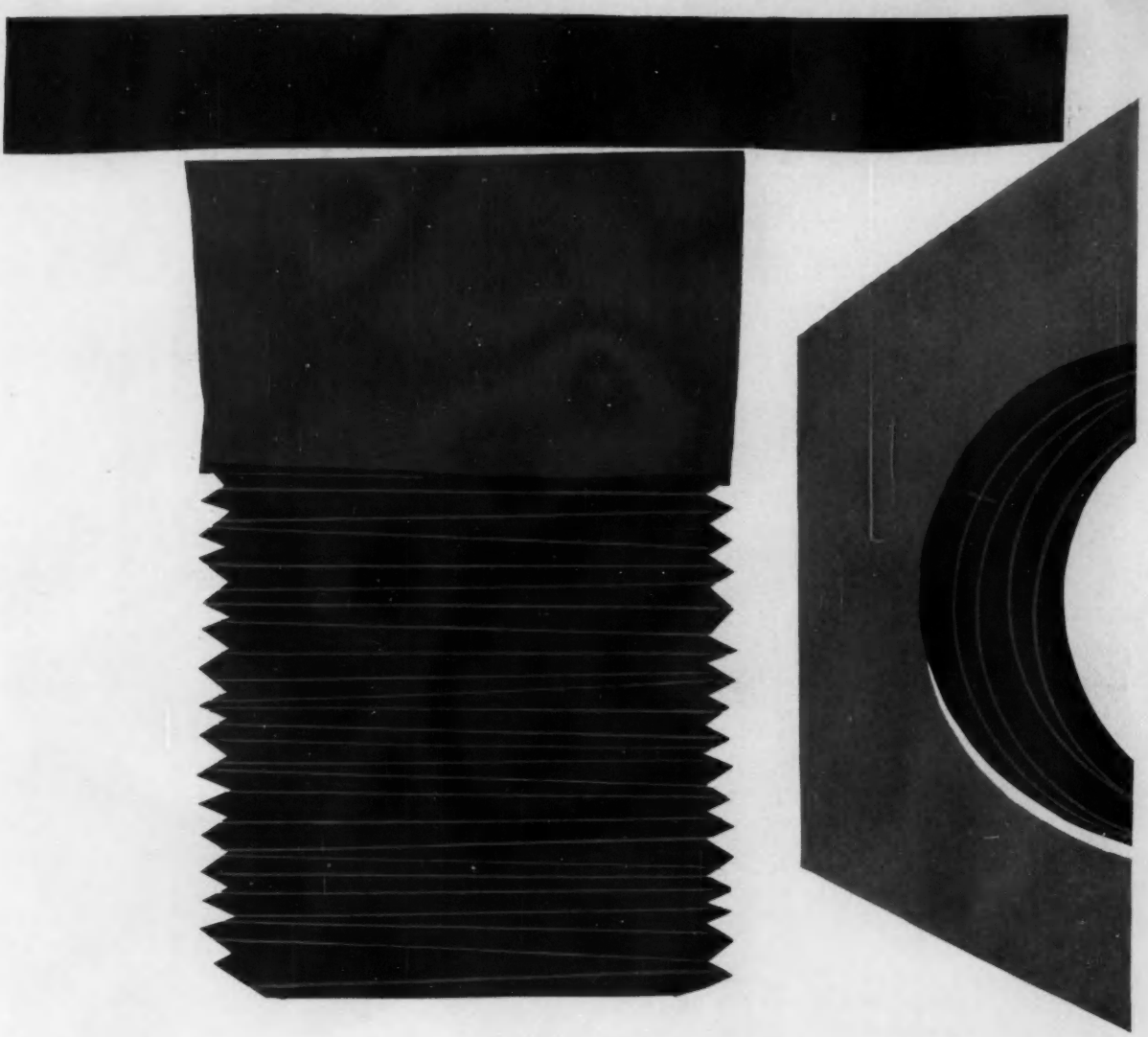


DANA Spicer **DANA CORPORATION**

Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions • Auxiliaries Universal Joints • Clutches Propeller Shafts • Power Take-Offs Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes Forgings • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario



imagineering the bold new look at Screw & Bolt that says "infinite design capability." Imagination, coupled with engineering, have led to endless new product design developments in fasteners and other threaded parts ■ Need a new design fastener or threaded part where standard shelf items just won't fit? Clip this ad to your letterhead and Screw & Bolt's sales engineers will put *imagineering* to work for you.

VMA 9387

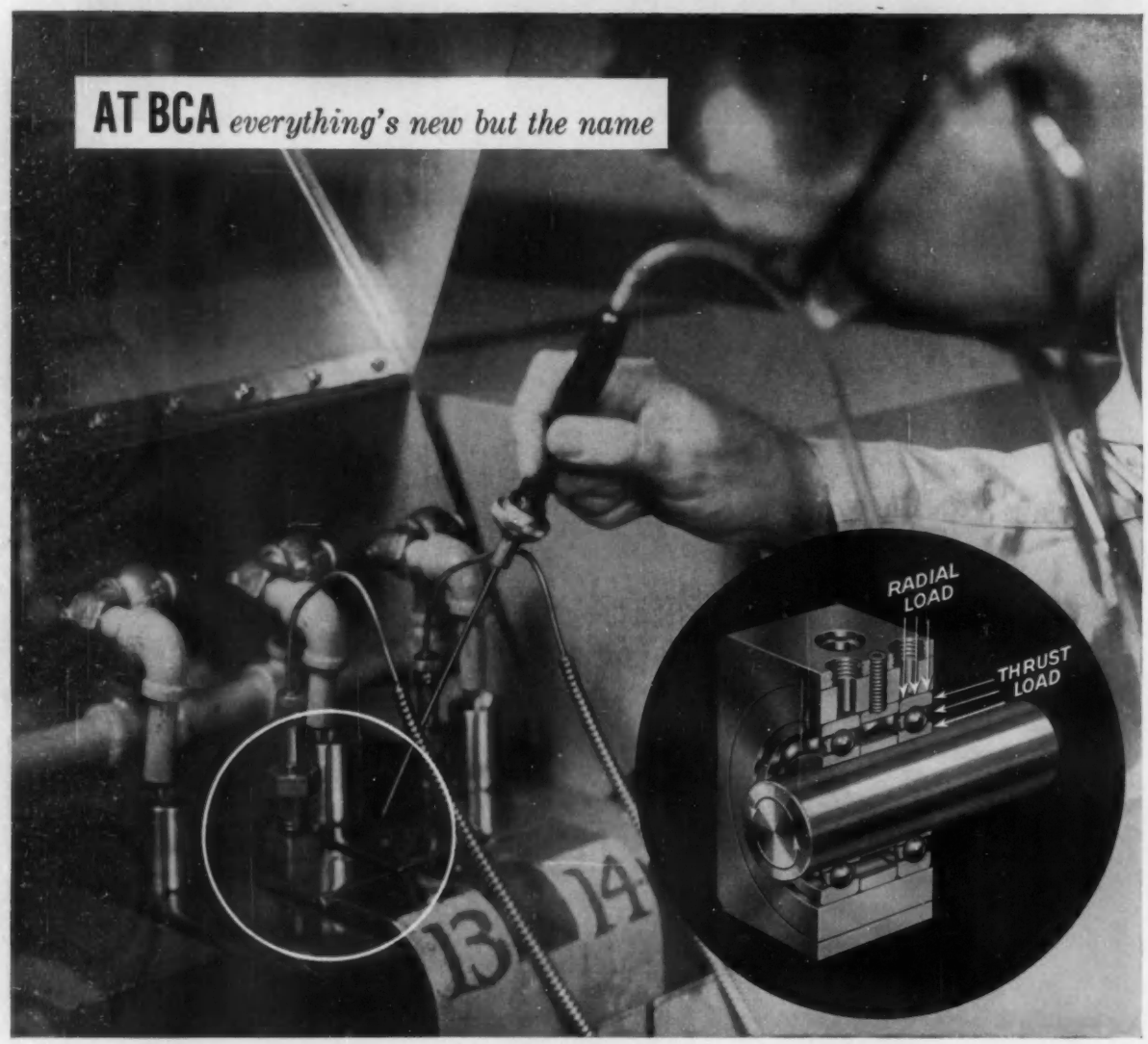
SERVES THE NATION

SCREW AND BOLT CORPORATION

OF AMERICA • P.O. BOX 1708, PITTSBURGH 30, PA.

Plants: Pittsburgh, Pa. Gary, Ind. Southington, Conn. Norristown, Pa. • Warehouses: Portland, Ore. Denver, Colo. Atlanta, Ga.

Imagineering... for greater fastener progress



BALL BEARING "HEARTBEATS"

checked with unique new fatigue tester

With a stethoscope checking the "heartbeats," this unique fatigue tester is putting BCA ball bearings through a battery of exaggerated, but controlled, speed and load tests.

The fatigue testing machines are part of a group of testing devices that provide essential data for BCA's research program. Hydraulically testing BCA bearings at a variety of rotational speeds and under many combinations of radial and thrust loads, each machine checks to see that BCA ball bearings are maintaining the highest fatigue life standards . . . evaluates the fatigue characteristics of new ball bearing materials and new processing methods . . . helps select ball bearing lubricants to provide the longest possible fatigue life.

These machines and BCA's other unusual testing devices are designed and built to help us develop the highest quality ball bearings available. By simulating actual operating conditions, BCA ball bearings can be tested to *exceed* customer specifications.

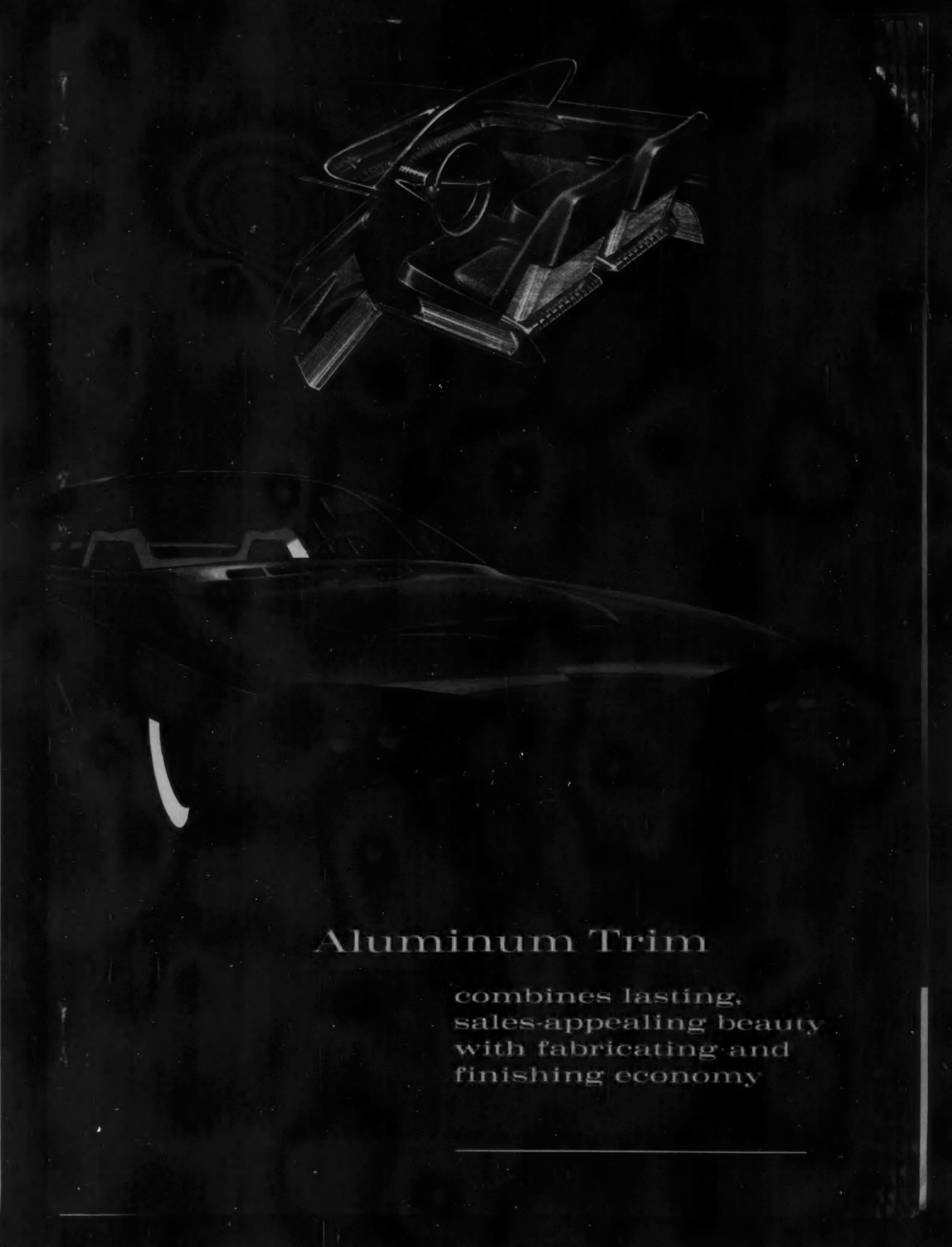
BCA ball bearings are standard equipment throughout industry—for both original and replacement applications. BCA's complete line of ball bearing types and sizes . . . design, engineering and manufacturing skill . . . plus research and testing facilities, are some of the reasons that automotive, machine tool, earth moving, agricultural equipment manufacturers specify BCA. We'd like to serve you—with high-performance bearings or technical assistance. Contact Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

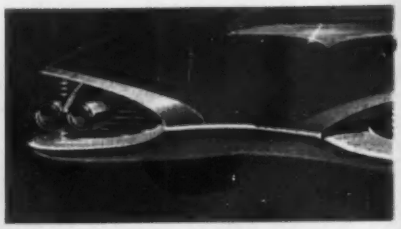


Aluminum Trim

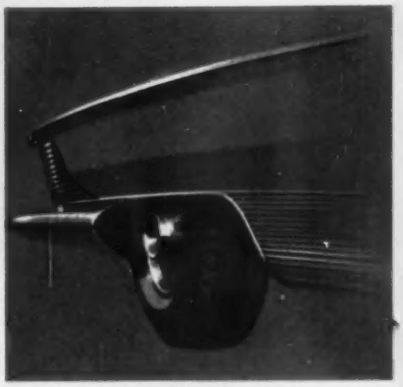
combines lasting,
sales-appealing beauty
with fabricating and
finishing economy

Exterior Trim

WINDOW AND PILLAR MOULDINGS



GRILLE AND GRILLE MOULDINGS

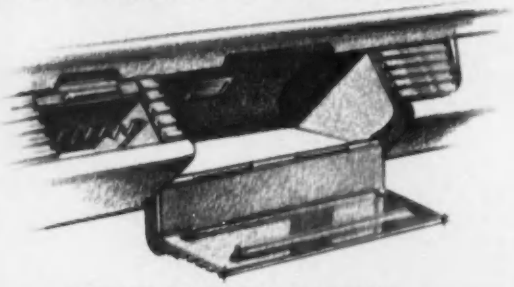


SIDE MOULDINGS

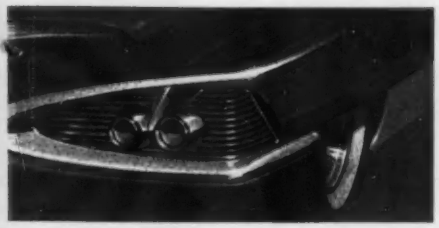
REYNOLDS ALUMINUM

Interior Trim

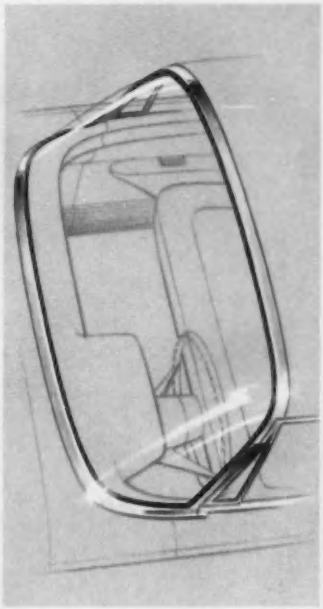
SEAT SKIRTS AND SEAT BACK TRIM



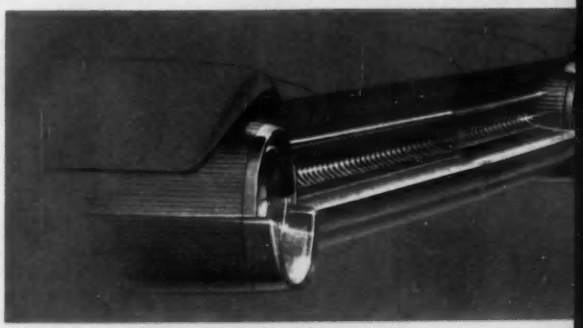
ASH TRAYS AND COVERS—
GLOVE BOX DOORS



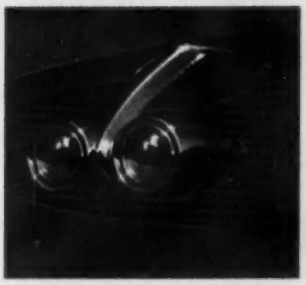
HUB CAPS—WHEEL COVERS



WINDSHIELD AND ROOF MOULDINGS

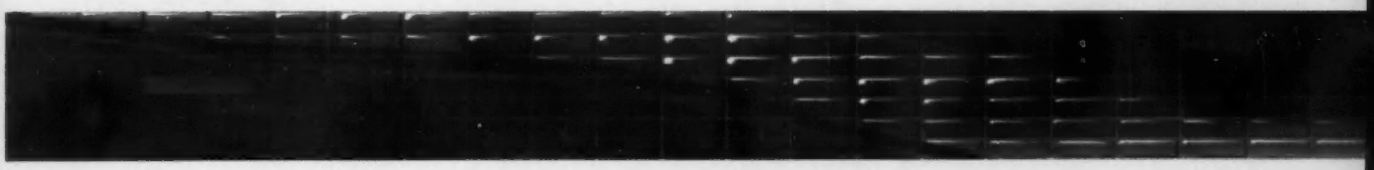


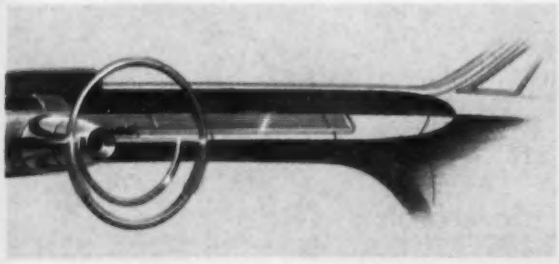
REAR BUMPER OR DECK TRIM—
QUARTER PANEL APPLIQUES



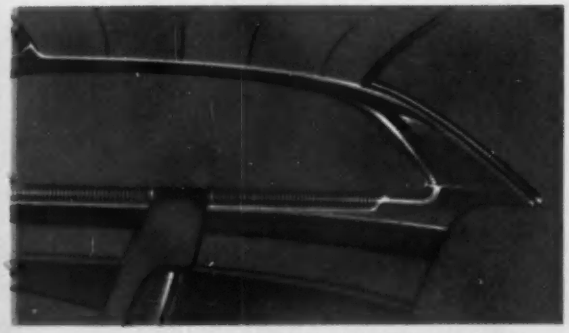
HEADLAMP BEZELS

TAIL LAMP HOUSINGS



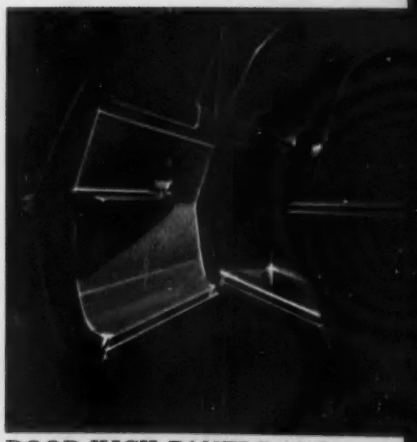


INSTRUMENT PANELS AND TRIM

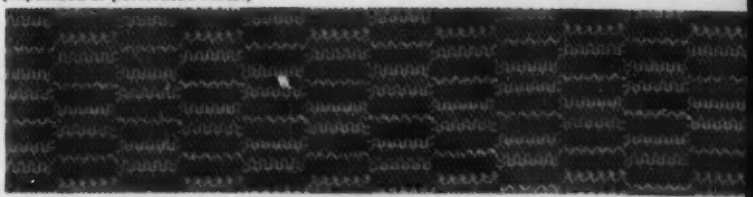


WINDOW MOULDINGS—
PILLAR COVER TRIM

RADIO SPEAKER GRILLE
(expanded or perforated metal)



DOOR KICK PANELS AND SCUFF PLATES



ALUMINUM YARN (REYMET)
TRADE MARK

Aluminum Trim

combines lasting, sales-appealing beauty with fabricating and finishing economy

Here are some of the reasons why you can get these important sales and manufacturing advantages with aluminum:

Aluminum's versatility in fabrication contributes to production savings and better part quality

There is one major reason why aluminum trim can save you money: *aluminum is adaptable to a variety of manufacturing techniques.* Because of this versatility, aluminum makes possible savings in tooling, fabricating, finishing and assembly costs—a combination of savings that cannot be obtained with other materials.

A good example is a typical aluminum exterior trim package. A standard package based on body mouldings, window mouldings, grille, grille opening mouldings, and hub caps runs $8.00 to $14.00 less per car than the same package in other metals. Conservatively, the average aluminum package saves $10.00 per car. Here are ways aluminum's versatility contributes to this saving.

Aluminum trim parts can be stamped, roll formed or extruded. As an example of the former, consider a side trim overlay framed with mouldings of another metal. This part can be made as a single aluminum stamping with embossing in the overlay area with bright surrounding mouldings—all in a single die. Tooling costs can be reduced. Substantial savings in assembly costs can also be realized. Similar savings can result from the roll formed aluminum approach as effectively used in several 1961 models. Although more commonly used in areas other than side trim, aluminum extrusions are still another approach where unusual variations in styling and design can be obtained with extremely low tooling costs.

Aluminum's versatility in finishing is an important cost and quality advantage

In finishing, aluminum's versatility again pays dividends in reducing part costs and improving part quality. Aluminum can be clear or color anodized. Contrasting colors can be added through the use of organic finishes. And, paint films adhere to anodized aluminum better than to other bright materials used for decorative applications. Warranty costs are reduced. A better appearance is assured over a longer service life.

Parts made of other metals must be buffed for maximum corrosion resistance. Some moulding parts, if not buffed on the back and edges, will rust with subsequent bleeding over the painted surface of the car. *Aluminum will not rust—ever.* Anodizing aluminum parts is much less expensive than chrome plating other materials. The final piece price of anodized aluminum parts is even less expensive than chrome flashed parts.

New aluminum textures and finishes contribute to design freedom and add sales-appealing beauty

There are wide varieties of aluminum textures, finishes and color combinations available to complement modern automobile exteriors and interiors. This variety is of particular interest in interior trim styling where aluminum trim parts lend themselves to a wide range of design ideas and also permit low cost styling changes.

Why it helps to call on Reynolds for trim package planning

The examples above are just a small part of the fabricating and finishing cost story made possible by strong, lightweight, rustfree aluminum—Reynolds Aluminum. For full details, talk to Reynolds Aluminum Specialists. These men are experienced in working with automotive companies on aluminum requirements, and they can put Reynolds many services and facilities to work for you. They will help you plan an aluminum trim package that will save you money and also help improve your products. Write or phone *Reynolds Metals Company, P.O. Box 5050, Detroit 35, KEnwood 7-5000. Or contact your nearest Reynolds office or write P.O. Box 2346-MZ, Richmond 18, Virginia.*

NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower final cost.

REYNOLDS ALUMINUM

the metal for *automation*

TRADE MARK

Watch Reynolds TV show "Harrigan & Son", Fridays—ABC-TV.

Piston Rings...
Sealing Rings

Call on

McQUAY-NORRIS

For more than fifty years McQuay-Norris engineers have worked side by side with original equipment engineers in the design of quality piston rings and sealing rings. With this experience you can be sure that McQuay-Norris can produce rings to your exact specifications, with delivery when and as you need them.

McQUAY-NORRIS MANUFACTURING CO., ST. LOUIS • TORONTO

With the right woven pile from Schlegel

Moving this window up or down strains neither muscle nor motor.

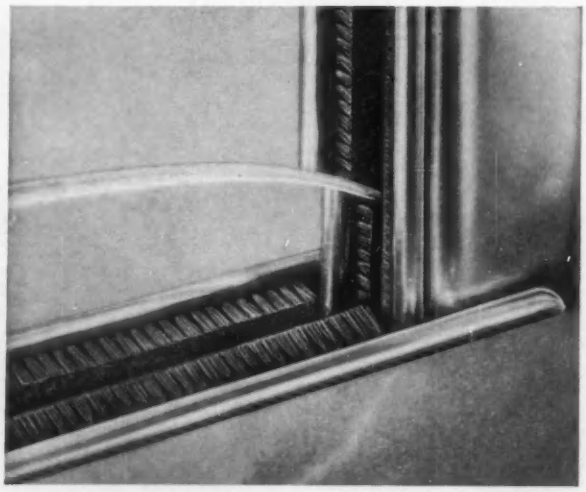
This is a significant accomplishment, considering the glass variances in today's automobile windows How does Schlegel pile liner make the job so effortless—yet still effectively seal out the elements and eliminate window noise?

The answer is yours. You select the glass run channel and specify Schlegel woven pile liner. We furnish the channel manufacturer with pile fabric of the correct specifications.

Our work doesn't end there. We give you a quality pile which will retain its wear-resistance for years and years to come.

To you (and your car-buyer), Schlegel woven pile liner means easier window movement, rattle-free windows and better sealing qualities. It hugs the glass surface evenly, flexing against wavy surfaces to hold a constant seal.

If that sounds good enough to make you want the best, be sure your next glass run channel utilizes Schlegel woven pile liner. You'll be in good company. Automotive engineers have been specifying Schlegel pile liner since glass windows were first used in cars.



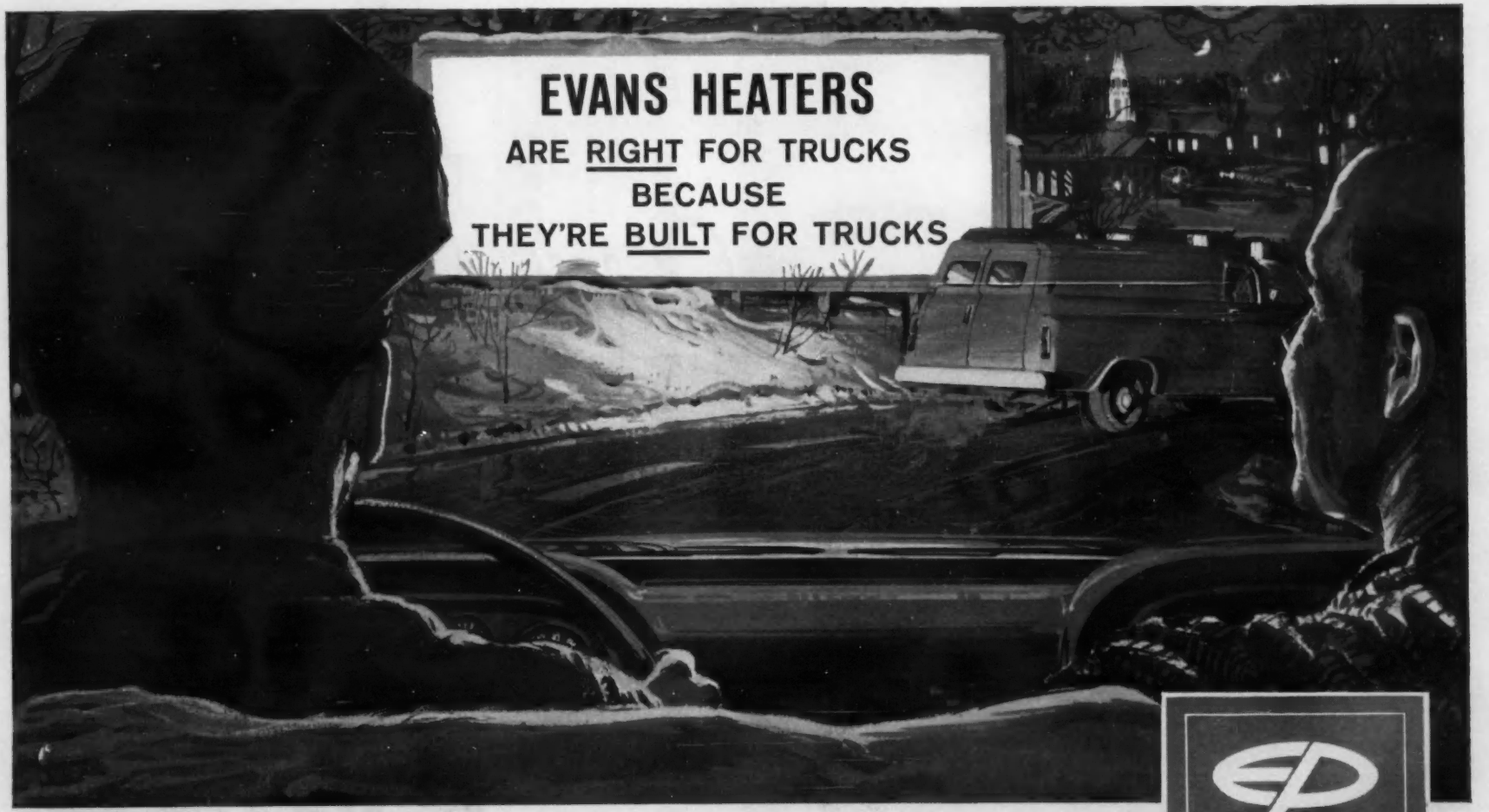
Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile

Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N. Y.
In Canada: Oakville, Ontario



Evans heaters are durable, dependable, rugged—*built for trucks!* They're tailored to truck manufacturer specifications, custom-engineered to provide the *right* BTU rating and heat distribution *for your specific truck models.* They're designed for quick, easy maintenance.

Product quality has made Evans the largest manufacturer of heavy-duty truck heaters. Evans' heater production is backed by 25 years of engineering experience, rigorous tests and assembly-line inspections. And backing each individual Evans heater is a one-year/50,000-mile warranty.

Our engineers are ready to work with yours to design an Evans heater to meet your requirements. Write Evans Products Company, Dept. Z-7, Plymouth, Mich.

Hallmark of Quality Products

EVANS PRODUCTS COMPANY
PLYMOUTH, MICHIGAN
HEATING AND VENTILATING DIVISION

REGIONAL REPRESENTATIVES: Chicago, R. A. Lennox • Detroit, Chas. F. Murray Sales Co. • Allentown, Pa., P. R. Weidner

for a quality product

use a quality "O" ring

be safe with PRECISION!

Precision "O" Rings are engineered specifically for your product! They're made to do the job better... longer. They meet all military and commercial specifications. Precision "O" Ring quality is maintained by over 100 inspections and quality control tests. There's a size and compound to meet YOUR requirements. If it's Precision – it's Precision-made! Write, wire, or phone for data sheets or help of a Precision Sales Engineer today.

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

3110 Oakridge Drive, Dayton 17, Ohio **Canadian plant at: Ste. Thérèse de Blainville, Québec**

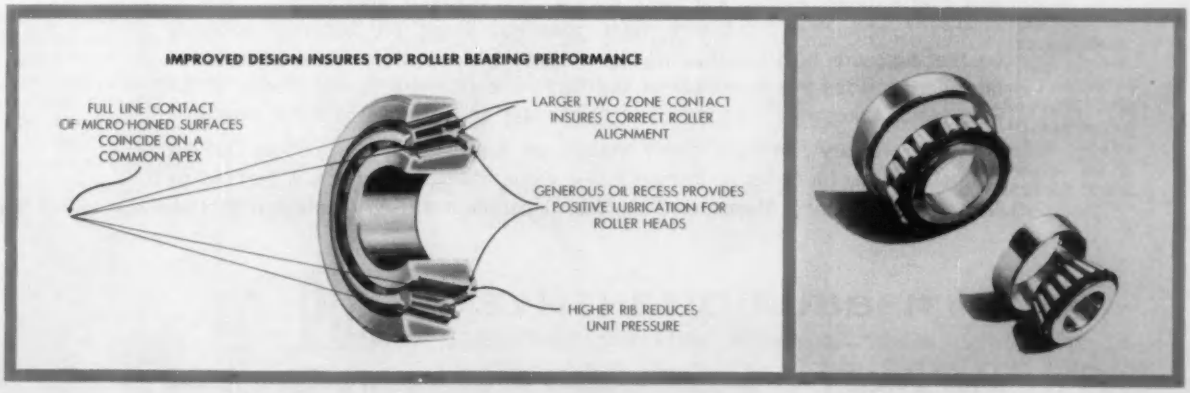
CRUEL TURNS, RAW SPEED—VICTORY RIDES ON ROLLER BEARINGS!

This pit stop is for tires, gasoline, *but no repairs!* Winning the race against time and keen competition demands peak performance from every mechanical component . . . no matter how violent the torture. Roller bearings, for instance, must perform so well they can be taken for granted. This is a familiar challenge for Bower engineers. Their many original contributions to roller bearing design have helped improve performance, minimize maintenance and reduce bearing failure to a rarity. That's why Bower Roller Bearings are widely used by the automotive and practically every other type of industry. If your product uses bearings, select from Bower's complete line of cylindrical, tapered and journal roller bearings. For technical assistance, write Bower Roller Bearing Division, Detroit 14, Michigan.

BOWER ROLLER BEARINGS

tapered cylindrical journal

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.


IMPROVED DESIGN INSURES TOP ROLLER BEARING PERFORMANCE
FULL LINE CONTACT OF MICRO-HONED SURFACES COINCIDE ON A COMMON APEX
LARGER TWO ZONE CONTACT INSURES CORRECT ROLLER ALIGNMENT
GENEROUS OIL RECESS PROVIDES POSITIVE LUBRICATION FOR ROLLER HEADS
HIGHER RIB REDUCES UNIT PRESSURE

FORD MOTOR COMPANY PROVES THERE'S MILES OF DIFFERENCE BETWEEN ORDINARY RUBBER AND DU PONT ELASTOMERS

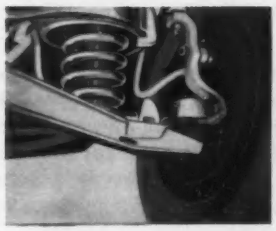
The Ford Motor Company didn't establish its 12,000-mile warranty capriciously. Components in every member of the Ford family of fine cars were checked, evaluated, proved or improved for long-term reliability and quality. In any single part, a few cents' upgrading at the factory might preclude a $50 repair in the field.

And for resilient parts—especially critical parts operating under difficult conditions—Ford turned again and again to Du Pont synthetic rubber to take over problem jobs that ordinary rubber just can't handle. For example, applications involving ruinous combinations of searing heat, gasoline vapors, oil, constant abrasion, weather exposure, high electrical voltages, ozone concentrations, extreme loads. In fact, Ford utilizes every member of the Du Pont elastomers family. Today, all of Ford Motor Company's 1961 cars and trucks use at least two of these products.

Where ordinary properties aren't enough, we suggest you, too, look to Du Pont synthetic rubber for better performance. For more information write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE-8, Wilmington 98, Del.

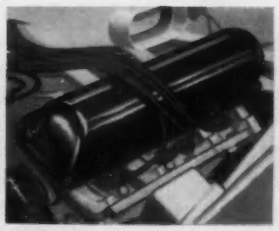
DU PONT SYNTHETIC RUBBER MAKES TODAY'S PRODUCTS BETTER... TOMORROW'S PRODUCTS POSSIBLE

FORD MOTOR COMPANY USES THE ENTIRE DU PONT SYNTHETIC RUBBER FAMILY IN ITS 1961 CARS AND TRUCKS



ADIPRENE® ball joint seal is the key to Ford's new front suspension, which helps keep factory lubrication good up to 30,000 miles. Other advantages: outstanding abrasion resistance, high load bearing capacity and oil resistance. Long-wearing ADIPRENE is also used for gear selector linkage bushings.

NEOPRENE engine mounts are used by Ford because of neoprene's unique combination of properties – heat and oil resistance; good dynamic characteristics; low compression set and outstanding flex resistance. This versatile synthetic rubber is also used for heater hose, tail-gate seals, trim adhesives.



HYPALON® ignition cable jackets and spark plug boots provide superior protection against electrical failure. They defy heat, ozone, weather and abrasion ... important factors behind Lincoln Continental's 24,000-mile warranty. Durable HYPALON is also used for bumper seals on the new Thunderbird.

VITON®, used in Ford truck carburetors and valve stem oil seals, performs reliably where other synthetic rubbers fail. Valve stem seals, for example, have given up to 150,000-mile service without failure. VITON remains stable at temperatures up to 600° F., resists aromatic fuels, lubricants, hydraulic fluids.

DU PONT

SYNTHETIC RUBBER

NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

Smooth output at lowest shaft speeds . . .

NEW WEBSTER HYDRAULIC MOTOR WITH INTEGRAL GEAR REDUCER

SPECIFICATIONS:

Models: 5, with a torque range from 39 to 142 inch pounds per 100 psi.
Input flow: Gpm at 1000 psi —
2.2 to 5.8 at 100 rpm output speed
4.9 to 15.5 at 300 rpm output speed
7.5 to 25.1 at 500 rpm output speed
Gear reduction: 4.65 to 1
Operating pressure: up to 2000 psi standard
Pumping gears: smooth-running spur involute — precision hobbed from alloy steel
Motor drive: free-floating internal spline
Seal: mechanical face-type on drive shaft
Porting: 1" NPT inlet and outlet standard, 1¼" "O" ring straight thread optional. ¼" NPT drain port.
Mounting: SAE-type "D" four-bolt mounting standard
Drive: Direct, gear or belt
Weight: 48 to 51 lbs.

This new Webster gear-type fluid motor combined with a planetary gear reducer was designed for high torque, low speed operations. High reduction ratio (4.65:1) assures smooth output at lowest shaft speeds!

The unit is extremely compact and provides stable, constant speed operation under varying loads. When used with a variable output flow divider, it becomes the high torque output element of an infinitely variable transmission. It is ideal for indexing, turning and transfer mechanisms; hydrostatic drives, winches, reels; turning or tilting units; batch mixers; driving elevators, conveyors — even earth augers.

The Webster motor-gear reducer has other important advantages: it may be used where it is impossible to use an electric motor because of explosion hazards . . . planetary gear assembly is lubricated by the hydraulic system . . . "straight through" drive between input and output shaft . . . mounts on an SAE standard, 4-bolt D size hydraulic pump mount. Drive is direct, gear or belt.

Your Webster Electric representative can tell you more about this interesting new hydraulic motor with integral gear reducer — or write direct for engineering detail sheet HY6-I.

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

Please stop in — Booth 400 — SAE Engineering Display, Milwaukee

JOURNAL

For Sake of Argument

Responsibilities and Opportunities . . .

EVERY JOB has responsibilities and opportunities. Most of us are pretty clear about our responsibilities; less certain about our opportunities.

This greater sensitiveness to responsibilities is partly because other people in general — and our boss in particular — help to keep us aware of what we're supposed to be doing.

Opportunities are something else again. We hear generalities about them when we start on a job. But what we hear is, at best, somebody else's ideas. Before the boss finishes explaining our opportunities, he may well have thrown them right in the pile with our responsibilities. He may just have given us something else to worry about.

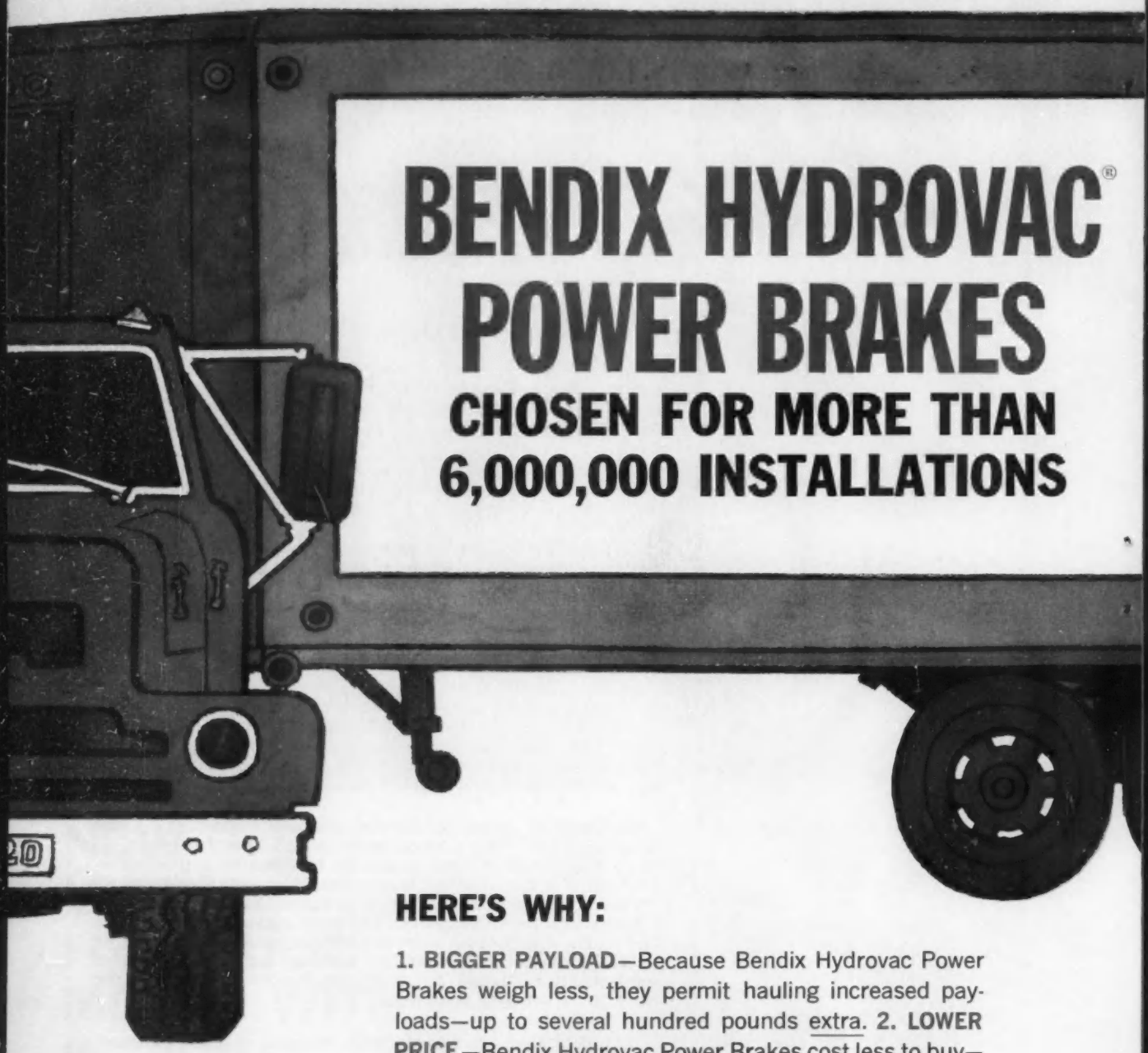
And that's too bad, because moving in on opportunities is the "fun" part of any job. But it's most fun only when we're moving in on what we have managed to spot for ourselves. When we see an off-tackle hole for ourselves, we've got an opportunity. It's ours to try for a gain or decide to drop at the scrimmage line to prevent losing ground.

It's the little opportunities that are most important . . . the opportunity to write a more friendly and effective letter; to bring the minds of some associates to focus on a problem — when they've been hurling tangential arguments at each other for weeks; to surprise the boss with that little widget redesign a few days before he expects. The daily opportunities outrank the yearly ones because there are so many more of them. Only by realizing the little ones can a fellow get in **the habit of opportunity-realizing**; be ready automatically to realize the big ones when they show up.

The best anybody can do with responsibilities is to meet them fully. The worst one can do with an opportunity is to gain a new experience.

The fellow whose mind tips toward opportunities leads the happier business life.

Norman G. Shidle



BENDIX® HYDROVAC® POWER BRAKES

CHOSEN FOR MORE THAN 6,000,000 INSTALLATIONS

HERE'S WHY:

1. **BIGGER PAYLOAD**—Because Bendix Hydrovac Power Brakes weigh less, they permit hauling increased payloads—up to several hundred pounds extra. 2. **LOWER PRICE**—Bendix Hydrovac Power Brakes cost less to buy—also less to operate, less to maintain. 3. **BETTER PROTECTION**—Bendix Hydrovac Power Brakes have built-in standby safety; manual braking in case of power failure.

MORE BENDIX HYDROVAC VACUUM POWER BRAKES ARE IN USE THAN ALL OTHER MAKES

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

chips

from SAE meetings, members, and committees

PLASTIC COATINGS PROTECT PRINTED CIRCUITS — Printed circuit assemblies in certain military equipment are being dip-coated with plastics to reduce abrasion damage to the circuits and to provide protection against humidity and corrosion. The plastic layer can be broken by a soldering iron — or a knife in some cases — for circuit repair.

The perfect coating material still hasn't been found; but epoxy formulations appear best at present — at least for applications in the moderate temperature range.

ROLLING RESISTANCE AND AERODYNAMIC DRAG on motor trucks are equal at about 60 mph, say GM researchers Harold Flynn and Peter Kyropoulos. For a truck of approximately 55,000 lb gross vehicle weight each is about 100 hp at that speed. . . . Reductions in drag as high as 37% are possible by changing from a square to a round trailer front, their studies show.

AS LITTLE AS ONE-HALF INCH OF SLUSH on an airport runway can seriously hamper a jet transport take-off. A rough rule of thumb developed from data obtained in NASA tests is that for each half inch of slush or water on the runway, 1000 ft more of ground run is required for the plane to take off.

BALANCE MACHINERY needs improvement, say Buick engineers F. R. L. Daley and R. J. Christensen. Balancers currently available, their experience in recent driveline studies indicates, show a lack of discernibility in that they cannot see small amounts of unbalance clearly. Fixtures for holding shaft assemblies while balancing sometimes introduce more error than the amount which is to be corrected. . . . Even the best of engineering-type balancing machinery, they say, gives different answers when shafts are indexed 180 deg — or taken from the machine and put back exactly as before. This, of course, renders cross checking extremely difficult and argumentative.

. . . COMPUTER RESULTS also leave much to be desired in current application to driveline studies, the Buick researchers feel. They say: "Massive help has been received in the use of both analog and digital computers in our present driveline development. We clearly sense, however, the best computer output is no better than its relation to reality. The analytical methods now in use do not correlate well with subjective results obtained in driving the finished automobiles. . . . Needed are ways to sort out the elements which count and tell the computers how to discriminate good practical results."

more chips on next page

HERE IS THE GROUND SUPPORT EQUIPMENT (GSE) currently needed for the operational intermediate-range ballistic missile (IRBM) shown in the center of the illustration. The standard equipment furnished by the government (GFE) is shown above the standard customer-furnished equipment (CFE). Included are guidance systems, launching equipment, and mobile field vans for field check-out adjustment. . . . From 1958 to 1961 Air Force expenditures for such GSE has almost doubled (from $781,300,000 to $1,250,700,000).

chips

from SAE meetings, members, and committees

DESIGNING LIGHT AIRCRAFT with survival in mind is important, since accidents seem to be unavoidable, says Piper's Karl H. Bergey. In all civil flying (excluding public air carriers), he points out, the accident rate per hour has remained remarkably constant over the past six or seven years . . . despite great improvements in radio aids and flight controls. Apparently the users have been willing to fly into increasingly marginal situations. (see story beginning on p. 54.)

CRITICAL LOAD FACTORS for the foil systems of hydrofoil ships are comparable to those for aircraft, according to Boeing's Richard G. Merritt. For ship foil systems, he says, the critical load factors "will probably lie between 3 and 5, depending upon the severity of the maneuvers required and the factor of safety. . . . A high performance fighter aircraft might be designed for 8 factors, while a transport aircraft might be designed for 2.3 factors based on material yield." In general, three types of load factors . . . acceleration load, dynamic load, and safety factors . . . are used to arrive at a set of critical loads for a structure.

DURING RUSH HOUR in the New York City subway the volume per passenger dips to about 15 cu ft per passenger (design minimum is 10 cu ft). By way of comparison, first class passengers on today's airliners are alloted more than 60 cu ft each.

ONE SMALL PINCH of an additive to transmission oil can, under the right conditions, completely eliminate "squawk" in a clutch engagement. The size of this small additive adhering to the plates at the interface is of the order of a dimension 0.00000008 in. in thickness.

PREFIXES FOR MULTIPLES AND SUBMULTIPLES — The Dept. of Commerce, National Bureau of Standards has recently adopted, for implemenation in the U.S., the eight prefixes in common use and the four new prefixes as listed below:

Multiples and Submultiples			Prefixes	Symbols
1,000,000,000,000	equals	10^{12}	tera*	*T*
1,000,000,000	"	10^{9}	giga*	*G*
1,000,000	"	10^{6}	mega	*M*
1,000	"	10^{3}	kilo	*k*
100	"	10^{2}	hecto	*h*
10	"	10^{1}	deka	*dk*
1	"	10^{0}		
0.1	"	10^{-1}	deci	*d*
0.01	"	10^{-2}	centi	*c*
0.001	"	10^{-3}	milli	*m*
0.000,001	"	10^{-6}	micro	μ
0.000,000,001	"	10^{-9}	nano*	*n*
0.000,000,000,001	"	10^{-12}	pico*	*p*

*new prefixes

PUSH-TYPE TOWBOATS on western rivers are more highly automated than any ship. Diesel engines are expected to run as long as 15,000 hr between overhauls and in the course of a year they can consume fuel equivalent in cost to their own price.

UNWORKABLE . . . That's what the internal combustion engine would be if not for the boundary layer of stagnant gas in the cylinders. Without this layer of gas to resist heat flow, heat would flow so rapidly to the cylinder walls that the engine would not work.

FORD'S CONSUMPTION of gaseous-shielded automatic arc-welding electrode runs about 1,000,000 lb per year. 10,000,000 cu ft per year of carbon dioxide shielding gas is used for welding such products as starter and generator frames, rear axle housings, frames, automatic transmission components, and bodies.

RIDING COMFORT, it has been found, is more adversely affected by motions perpendicular to the spinal column than along it. This indicates that pitching oscillations should be given greater attention than lifting oscillations.

SUPERSONIC EXPERIENCE on U. S. airframes (such as the F-100 fighter) is equivalent to that accumulated on present transports in two to five days. Some 25,000–60,000 hr are estimated to have been flown supersonically. This compares to an average total of 12,700 hr utilization per day for U. S. airliners.

DROPPING EGGS 150 ft without breaking the shell has been done using a 1½-in. thick mat of energy absorbing foam, such as that used in safety padding.

members answer members' questions on

Piston-ring and cylinder-bore wear

Free discussion between SAE members at Engine Workshop session unveils current engine wear problems. Causes . . . Solutions . . . illuminate session planned by Subcommittee on Engines, SAE Passenger Car Activity.

Taped session edited by **W. S. James**
for the Engine Subcommittee of the Passenger Car Activity Committee
John S. Wintringham, chairman; **W. S. James, R. J. Templin, H. L. Welch, A. E. Cleveland**

Which causes more destructive wear, dirt in the combustion chamber or dirt in the oil?

Wear from air-borne dirt

Parts worn

Most of the wear resulting from significant amounts of air-borne dirt entering the engine via the intake system will occur on the top compression rings and the upper portion of the cylinder bores.

Wear resulting from dirt entering via the ventilating air and the crankcase oil will occur on the main and connecting rod bearings and the oil control rings.

Both kinds of wear can be serious.

Repair costs

Service corrections for the damage to the upper portion of the bore and the top rings are more difficult and expensive than damage to the bearings.

Air cleaner efficiencies

Frequently the air cleaner on the intake system will remove all but less than 1% of the dirt in the air passing through it, but the air cleaner on the ventilating system may pass as much as 20% of the dirt approaching it. Under these conditions, when the intake air (e.g. 40 cfm) is 20 times the ventilating air (e.g. 2 cfm) the same amount of dirt will enter the engine via the crankcase ventilating system as through the intake system.

Tractor practice

In the tractor industry, where very considerable quantities of air-borne dirt are encountered in normal operation, one company has long used a crankcase ventilating system in which a small vane pump draws air from the intake system below its air cleaner, pumps it through the crankcase and discharges it into the open air. A positive pressure of about 0.2 in. H_2O is maintained in the crankcase. With this system the dirt is removed from the ventilating air with the same high efficiency as from the main stream of intake air.

Wear from lead in the fuel

Engine designer's interest

The engine designer is particularly interested in the influence of fuel additives on engine wear, should it occur, because he cannot take steps to reduce or eliminate it as he can in the case of air-borne dirt.

continued on next page

Laboratory engine tests

Engines have been run for hundreds of hours in the laboratory with leaded fuel without any serious wear having been observed that was attributable to the use of leaded fuel additives.

European lead levels

Lead levels in European fuels are approximately half those used in this country. Engine mileages between major overhauls are believed to be greater in this country than in Europe, even with the distinctly greater quantities of lead used in the fuels.

Of course, there are other factors involved in trouble-free mileages than lead in the fuel.

Comparative wear tests

Laboratory and proving ground tests, carried out in the 1940's with the cooperation of an oil company and using a group of engines half of which were run on unleaded fuel and the other half on the same fuel except for the addition of 3 cc of lead, showed a slight but consistently greater wear in the engines using the leaded fuel. The increased wear, although clearly existent in practically all parts of the engines, was not considered to be of sufficient amount to be of practical importance.

The engines used identical crankcase oils.

What is the mechanism of scuffing of bores and rings?

Basic mechanism

Scuffing of rings and bores, basically, is believed to be a kind of welding process in which the welds are initially very small in area. It is often spoken of as "adhesive" wear.

Anti-weld oil additives

Clean iron surfaces in contact at high enough temperatures will weld quite readily. If the surfaces are dirty or coated with a nonmetallic film, this welding tendency is very much reduced and sometimes entirely eliminated. Compounds of sulfur or phosphorus are often used in crankcase oil additives to produce these weld preventing films.

Start of scuffing

Most of the scuffing starts near the top of the bore where the temperature is highest, the lubrication poorest, the piston speed the lowest, and the presence of air-borne dirt particles most likely.

Pinned rings

When rings are pinned to prevent their rotation, scuffing may be accentuated because the weld spots will continue to contact each other, whereas with unpinned rings, which can rotate, the lightly scuffed or welded spots will heal many times instead of grow.

"Severe" rings

There is some evidence that nonconformity of the oil ring with the bore will cause scuffing. This may be particularly true if the oil ring is poorly designed and has areas of high pressure which will tend to accentuate scuffing. Such rings are often called "severe" because they tend to scuff. The scuffing may be due to these areas of high pressure rather than a tendency to dry-up the bore. Such rings often have very poor oil control.

The elimination of the high pressure spots by a redistribution of the pressure will often stop the scuffing and give satisfactory oil control.

Poor macrogeometry of the bore

When measuring bores with a Tolleyrond, rather than an air gage, the variation of the bore from a true circle is indicated and it is often found to be a true circle for only two-thirds or three-quarters of the bore and there is either a pocket or a bump in the remaining portion. In the case of a pocket the portion of the ring bridging this pocket is unsupported and the unit pressure on the portions of the ring in contact with the bore increased. In the case of a bump there is an obvious increase in the wall pressure at that point.

Due to high pressures on the hones, for fast stock removal, there are probably more cases of hollow spots than bumps. It is believed that these areas of high unit pressure caused by poor macrogeometry of the bore often cause scuffing.

Surface "roughness"

Measurements of bore "roughness" in terms of rms microinches are average values and do not reflect the character or desirability of the finish of the surface. The bad experience of almost everyone in the industry with "superfin-

ished" bores tried when "superfinish" methods were in vogue, clearly demonstrated that absolute smoothness of cylinder bores is not desirable.

Bore finishes with rms readings of 6 micron. and less proved very vulnerable to scuffing. Current practice judged by rms readings is 15–30 microin. Different types of surfaces, some good and some bad will be within this range of average roughness as measured by rms microinches.

A type of surface finish that has proved very satisfactory is a "cross-hatch" or "cheveron" type. This finish is obtained by using a good hone cutting clean *V* grooves about 0.00015–0.0003 in. in depth and 0.0002–0.0009 in. in width spiraling up and down the bore at an angle of 22–32 deg from the horizontal. The right and left hand spirals crisscross in a cross-hatch type of pattern. The plateau area between the clean-cut tool marks should be about two-thirds of the total surface. A surface finished in this manner will have a roughness reading of from 15–30 microin. rms and averaging 20–25 microin.

If an improper hone, or one in poor condition is used the grooves will not be clean cut. The metal may be turned over or upset, not removed. When the engine is run-in this upset metal at the side of the grooves comes off and becomes a potential cause for ring and bore scuff. Faxfilms taken on such a bore when first honed and after 2,000 miles running will have a higher microinch reading after the run-in because of the burnished metal having worn off.

Naturally there should be no embedded metal on the surface after honing. When a properly cross-hatched bore has been run-in the cross-hatch is less pronounced but is still visible. New rings and bores have more wear debris than after they are run-in, when the graphite pattern in the bore should be able to take care of the wear particles.

Finish of used bores

In one experience with new and used liners, an endeavor was made to use a smooth finish of about 10 microin. on a new liner. The rings scuffed every time. When a used liner — with a rms reading of 5–7 microin., roughed up a little but not enough to change the rms reading — was run with new rings, absolutely no difficulty was encountered. Somehow the engine knows how to finish the bore better than we do.

Ring rotation

When discussing proper finish for bores, it should be noted that when the bore was honed with the spiral grooves in one direction only, the rings were observed to rotate. Such observation can be questioned because rings have been found to rotate in one direction when under power and in the other direction when the engine was motored.

It has been suggested that when cylinders are honed with the hones rotating in one direction only that the shape of the bore probably is not that of a cylinder but rather of a helix.

The real cause for ring rotation apparently is not known at this time.

Unexpected results

An old engine, which usually could be made to scuff if run hard enough and fast enough, was run one time with a clear gasoline and a low priced straight mineral oil for 100 hours with an unexpected result. It did not scuff. The bores looked like new with the tool marks still visible but there were no scuff marks. There still are some things we do not understand about ring and bore scuffing

How much do lubricants with high "anti-wear" qualities or chrome plated rings prolong break-in time?

Dimensional accuracy of rings

Neither high "anti-wear" lubricants nor chrome plated rings need prolong run-in time if they are properly designed and manufactured. The accuracy with which the chrome plated ring will contact a perfectly round gage placed around its circumference and along its face normally contacting the bore is increased by an amount about proportional to the decrease in ring wear due to the chrome plate. Unplated rings are held to an accuracy of 0.0003 in. and chrome plated rings to 0.0001 in. With these limits of bore contact accuracy maintained there is no need to prolong the run-in time of chromed rings or unchromed rings used with present heavy duty oils.

continued on next page

Non-additive oils for run-in

Some service people hold the belief that heavy duty or MS oils take longer to run-in and recommendations have been made to use non-additive oils in some cases of high oil consumption during run-in. An examination of all factors in such cases has led to the conclusion that if there is any advantage in using non-additive oils during run-in it is far outweighed by other advantages attendant to the use of MS oils.

When is an engine run-in?

In general, two criteria are used to judge when an engine's rings and bores have been run-in: — (1) Stabilized oil consumption and (2) Reasonable blow-by.

It is not possible to tell by a visual examination of the rings that they are run-in. The examination of rings giving good and bad oil consumption during run-in will not differentiate one from the other.

Run-in methods

Several years ago the proper run-in procedure was described by the number of miles an engine should be run at relatively low speeds. The principal worry at that time was: "Will the pistons tie-up or the bearings burn-out?" The use of additive oils and chrome plated rings probably has had more of an impact on run-in methods than on run-in time. The improvements in rings, bores, bearings, and lubricants have changed the worry during run-in to: "How much oil is it using?"

Now engines are put to work at once and not particularly "babied." If today's engines were run-in as the older engines were there probably would be a difference in the time required for running-in with chromed rings or "anti-wear" oils. Today's recommendations are to drive normally and avoid long stretches of high load, high speed operation for a thousand miles or so. Intermittent high speed and high load operation will help complete the engine's run-in.

What are the three most important factors in oil control?

"Attitude" of the top ring

If the top ring has an upward scraping attitude there will not be much you can do to obtain good oil consumption.

Bore distortion

If the cylinder bore is distorted for any reason — poor machining, incorrect cylinder head hold down bolting, temperature warpage, and such — the effect of good ring combinations will be overpowered.

Excessively wet bores

Excessive and unnecessary oil splash or oil throw-off from the crank and main bearings or the pressure relief valve onto the cylinder bores will overload the capacity of the oil ring and permit too much oil to reach the top ring. In one case an engine with adequate oil control was just turned around and immediately the oil control was lost. The oil pressure relief valve was throwing oil onto the camshaft which threw the oil onto the bores instead away from them.

Oil ring meters and distributes oil

There are two important functions of the oil control ring; (1) Meter the amount of oil reaching the top ring and (2) Distribute the oil around the cylinder bore.

The oil ring nearly always does a good job of distributing the oil around the circumference of the bore. Care must be taken however to adjust the metering of the oil getting past it so that there is enough to keep the top ring lubricated without using an excessive amount of oil.

The present type of oil control ring, two scraping edges with ventilation between them, was used in steam engines some 50 years before it was used in gasoline engines. In steam engines oil was injected through a hole in the cylinder wall and the ventilated ring was used to distribute it around the circumference of the piston for the lubrication of the piston and cylinder. This is generally unrecognized function of what is now called the oil control ring.

Minimum oil consumption

The oil consumption at which satisfactory lubrication ceases is difficult to measure and is probably different for every engine design and possibly between engines of the same design. A very thorough investigation of the Wright 1820 aircraft engine cylinder showed that at about 0.0003 lb of oil per hp the compression rings started to scuff. In general, at rated maximum horsepower and speed most engines will fall between 0.0005–0.0020 lb per hp per hr. Some engines have been known to run 10,000 miles per quart and show no excessive wear.

Two oil control rings?

Why not use two oil control rings? The shortening of the cylinder block to reduce engine height does not leave enough room to permit increasing the number of rings. The unit load on the single oil control ring has been increased so that it does an adequate job.

Why use a second ring?

The principal function of the second compression ring is to reduce the pressure drop across the top ring. It does little else (as evidenced by its low wear rate) but when an effort has been made to eliminate it the wear rate on the top ring has become too high for satisfactory operation.

Experiments in removing rings

In the early 1930's an engine manufacturer was having difficulty with oil control in an engine with three compression rings and one oil ring. When the top compression ring was removed and the groove left empty the oil mileage doubled. Repeated trials gave the same result. With the top ring groove empty there was a loss in performance about equal to what would be expected by a reduction in compression ratio explainable by the increase in clearance volume due to the empty ring groove. The normal groove was replaced by a narrow shallow groove. The second ring was not moved closer to the top of the piston and the improved oil mileage was maintained. This probably was the origin of the "heat dam" rather generally used in pistons today.

Some recent work has been done with a piston having two compression rings and an oil ring to find the effect of first removing the top ring and then the second ring. When the top ring was removed, leaving only the second ring and the oil control ring, no oil control was lost up to 55 mph, but at 80 mph 60% of the oil control was lost. When the top ring was put back and the second ring removed the results were reversed. At 55 mph 60% of the oil control was lost and at 80 mph the oil control was satisfactory.

With the top ring out the blow-by was 8% less at 2500 rpm than with both rings in. However, at 1500 and 4000 rpm the blow-by was increased 40%. When the second ring was removed and the top ring replaced the blow-by was increased by as much as 150%, and control of both oil and blow-by was lost at low speeds. With the top ring out and the second ring in the blow-by at low speeds was higher, about 40%, but it was still satisfactory. When the speed was increased above 3500 rpm both the blow-by and the oil control became unsatisfactory.

Two-ring pistons?

The time may come when a two ring piston will be developed to take advantage of reducing the height of the cylinder block.

What is the detailed action of blow-by and what is its composition?

Composition of blow-by

The latest information on the composition of blow-by is that it is largely unburned mixture from around the periphery of the piston that leaks by the rings during the last part of the compression stroke and the first part of the explosion stroke.

Condensed blow-by has been found to have a pH of about 2, very acid.

Blow-by paths

Blow-by occurs through the ring gaps, between the ring face and the bore, and behind the ring. The distribution of flow through the several possible paths depends on the geometrical fits of the rings in their grooves and in the bore as well as the combustion chamber pressure and piston speed.

continued on next page

Through ring gaps

Repeated tests have shown that blow-by is reduced by reducing the ring gaps but care must be taken in their reduction or serious ring butting and cylinder scoring will occur with high loads and temperatures.

Past ring face

An example of what was probably blow-by from leakage across the ring face occurred when an engine with very satisfactory blow-by characteristics was bored out 1/16 in. and the same ring combination used. The blow-by of the bored out engine was unbearable and was corrected by a change in the top ring. This experience might indicate that the 1/16 in. change in the bore reduced the ring face-to-bore pressure below that necessary to maintain the gas seal across the ring face.

Back of the ring

Blow-by back of the rings is probably controlled by the completeness of the seal between the bottom side of the ring and its mating ring groove. Laboratory tests have shown that with a given load as the speed is increased the blow-by increases along a smooth curve until a certain speed is reached, when the blow-by suddenly increases and then proceeds along another curve very definitely higher than the original curve.

If the test is repeated but at a lower load the sudden change from the lower curve to the higher curve will occur at a lower engine speed.

If, in the same engine, the top ring is replaced with one narrower and therefore lighter the speed at which the sudden change in blow-by from the lower to the upper curve occurs seems to coincide with that at which the inertia forces on the top ring are just balanced by the gas pressure in the cylinder and the ring no longer stays on the bottom of the groove, particularly on the compression stroke.

If the top ring can be made light enough it can be kept on the bottom of the groove during the entire speed and load range. The blow-by giving the lower curve in these experiments was probably a combination of leakage through the ring gaps plus that across the ring faces.

Critical speed & "flutter"

The up-and-down movement of the ring in its groove is called ring "flutter" and the speed at which it occurs with accompanying increase in blow-by, the "critical speed." At times a radial vibration of the ring has been observed, in which the gap opens and closes. This radial vibration is also called ring flutter. Both types of ring movement are probably caused by a balancing of gas pressures and the mass inertia of the ring at certain engine speeds and loads.

Blow-by and carburetion

Recently the importance of blow-by has increased due to the smog condition in California, and the use of ventilation systems in which the ventilating gases washing blow-by from the crankcase are being admitted to the intake system below the carburetor. In these installations proper carburetion is hard to maintain if there is an excessive amount of blow-by.

Blow-by, rust, sludge, and varnish

There is considerable evidence that the presence of blow-by in the engine crankcase increases the sludge formation in the crankcase oil. This not only tends to cause sludge to be deposited on the engine parts but it reduces oil filter life. The use of dispersant type oils reduces the tendency to deposit sludge and plug oil filters. If blow-by is not removed from the crankcase, significant difficulties will be encountered with corrosion, rusting, sludging, and varnishing of engine parts.

Ventilation and varnish

The preliminary results from an experiment were reported in which varying amounts of ventilating air, 0, ½, 1, and 3 cfm, were passed through the crankcase and the amount of a sort of varnish formed on the valve-gear noted. The worst "varnish" deposits were found with 3 cfm ventilating air and there were more deposits with 1 cfm than with ½ cfm.

The varnish found might have been due to the condensation of vapors normally found in the crankcase. The experiment was run at what would be considered much lower than normal oil and water temperatures to increase the formation of sludge and varnish deposits.

How should satisfactory ring-to-wall pressures be determined and described?

Design limitations

The design of rings is largely controlled by dimensional limitations and the mechanical properties of the materials used. With the exception of the unit wall pressures of the oil rings, engines are relatively insensible to specific

pressures of rings. Specific pressure is a design characteristic that influences the conformability of the ring to cylinder discrepancies and therefore it is kept at a relatively high value considering the yield point of the material. Beyond this you are limited by the prescribed radial wall dimensions, groove depths, and the ability to get the ring onto the piston.

Generally, design stresses are higher for installation than for operation and the specific pressure in oil rings (which is compounded of contact area and total expansive force), is a very important consideration in their design. The unit pressure between the cylinder wall and the face of the oil control rings varies but a good average value is about 200 psi. Many heavy duty engines have oil rings with wall pressures of 200–250 psi.

M P G vs M P Q

The balance between high oil mileage but lower fuel mileage, that goes with high unit pressure oil rings and lower oil mileage but higher fuel mileage that goes with less engine friction from lower unit pressure oil rings is a compromise that must be struck by each engine designer.

How much of the cylinder bore should be cooled and why?

Reduced oil temperatures

The use of a full length water jacket has been found to reduce oil temperatures. In one engine the lower one inch of the bore was uncooled and when the water jacket was made full length the oil temperature was decreased 20 F. This observation was confirmed by the experience of other engine manufacturers.

Bore distortion

The opinion was expressed that a full length water jacket reduced bore distortion because there was no sharp axial temperature gradient in the bore at the point where the water jacket stopped. This opinion was questioned, however, because of the success of Buick iron and aluminum engines that are built without full length water jackets and which have very round bores and as good ring and bore life as any engines in the industry. Because the lower portion of the bore is not cooled by water it is possible to run with a higher oil temperature and reduce the heat rejection to the radiator plus save copper and cost.

The differences in opinion on the advantages of long and short water jackets were resolved by considering a change in how the stress from the explosion pressures was transmitted to the crankshaft when the water jackets were lengthened. At the time the long water jacket was rather generally adopted, the stress from the explosion pressures was transmitted by the hold down cap screws through the uncooled section of the cylinder bore and this varying stress probably accounted for much of the distortion experienced, although at the time it was blamed on temperature gradients. Both factors may have played a part.

In more recent designs, such as the Buick engines, the head bolting stresses are carried through the water jacket directly into the main crankcase casting by ribs in line with the cap screw bosses. The water jacket is about 1–1½ in. shorter than the cylinder barrel but the unjacketed portion is free from any bolting stresses.

Comparing a solid iron bore with an iron lined aluminium bore, are there significant differences in the temperature gradients along the bore axis but near its surface?

Ferrous lined aluminium bores

With a really good bond between the aluminum and the iron there is a lower temperature gradient along an iron lined aluminum bore than along an iron bore. If the bond between the iron and the aluminum is not good there will be no advantage gained from the increased conductivity of the aluminum With a really good mechanical bond the temperature drop across the bond will be very small. In fact the difference between the temperature drop from the cylinder bore surface to the water is practically the same as through solid aluminum.

The effect of a heavy layer of aluminum on a thin layer of iron is much like the effect of too much insulation on a hot water pipe. The heat loss from the increased area of the heavy layer of insulation offsets the effect of the insula-

continued on next page

tion. If, in effect, you increase the surface area of the iron by a heavy layer of an excellent conductor you may actually increase the heat flow through the iron. In addition the tight mechanical bonding of a really rough iron surface with a rough aluminum surface will tend to increase the heat flow simply by an increase of the areas in contact. The bond referred to is a purely mechanical bond, not a chemical, molecular, or metallurgical bond.

What are the requirements of surface finish on rings?

The surface finish of rings is carefully controlled. There are quite a wide variety of finishes for various requirements. A definite thread form is used when a high degree of initial scuff resistance is required. Where initial oil control is important an almost dead smooth finish is used.

What life is expected of piston rings in trucks and buses compared with passenger cars?

Many truck manufacturers are advertising and some are guaranteeing 100,000 miles before major overhaul. Most passenger car engines seem to be designed for about 50,000 miles before overhaul.

The lower speed of the heavy duty engines, 1800–2400 rpm rather than 4500–5000 rpm may be one of the reasons why there is such a difference in ring life between the two types of service and equipment.

In heavy duty engines 200,000 miles is desired from a set of rings and although it could be obtained before World War II it is not being obtained today. Many truck operators are demanding 200,000 miles on a set of rings and more miles per quart of oil.

The oil mileage that is satisfactory in truck operation would not be acceptable for passenger cars. Most truck operators are satisfied with 500 miles per quart in the early life of the engine and some are afraid of much longer mileage. At 200,000 miles the oil consumption would be down to 150 miles per quart and at this time they would believe it necessary to re-ring and re-bore.

Is 0.010 in. of stock on diameter sufficient for reboring?

The adequacy of 0.010 in. of stock for reboring an aluminum engine was questioned. The first overhaul might not require reboring but the next overhaul might require more than honing.

In a recent overhaul job two of the cylinders were 0.005 in. out of round and could be cleaned up with a hone. When reboring, however, it is necessary to centralize the boring bar, get under the hard glazed skin and then hone. It is not believed possible to do this and remove only 0.010 in. of stock. There is a question about doing it under 0.020 in. It might well take 0.030 in.

A little bit more room would make a rebore job much more practical.

If cylinder bores become "glazed" does this increase oil consumption?

Although there was no opinion expressed on the effect of a glazed bore on oil consumption there was general agreement that it was desirable to de-glaze the bores when installing new rings to insure their proper run-in.

Some engine rebuilders have a reservation about removing the glaze because if it is improperly done the performance of the engine after rebuilding will be unsatisfactory. There are a number of good de-glazing tools on the market but in all of them it is necessary to use clean, sharp stones or they will put another glaze on top of the old one, usually with some abrasive trapped in it and the job is worse than before.

De-glazing a bore removes almost no material.

In some cases the bore is coated with a kind of varnish like material that looks like a yellow haze. Whenever this is encountered it must be removed.

Reduce distortion from grinding and milling operations

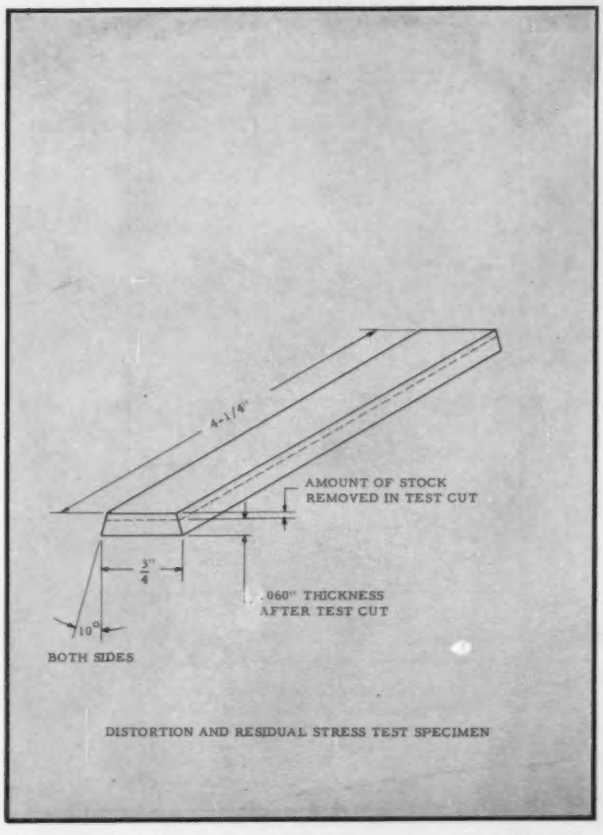


Fig. 1 — Test specimen dimensions. The 10 deg taper ground on the sides of each strip was used to clamp the specimen in the holding fixture.

Flight vehicles are using more high strength steels with extremely thin cross sections. So, distortion of the workpiece is very important in maintaining close tolerances.

Based on paper by

L. J. Nowikowski, John Maranchik, Jr., and Michael Field
Metcut Research Associates Inc.

Test data show the factors contributing most to workpiece distortion from grinding and milling operations on high strength steels to be:

For grinding —
- Wheel grade: Increased wheel hardness increases distortion.
- Wheel speed: Increased wheel speed increases distortion.
- Down feed: The coarser the down feed the greater the distortion.

For milling —
- Cutter sharpness: As the cutter dulls, distortion increases.
- Cutting speed, depth of cut, and cutting fluid in themselves have a small effect on distortion. These factors are important in that they affect dulling of the cutter.

The distortion produced by grinding or milling was determined by measuring the change in flatness of the test specimen. Fig. 1 shows a sketch of the test

Reduce distortion from grinding and milling operations

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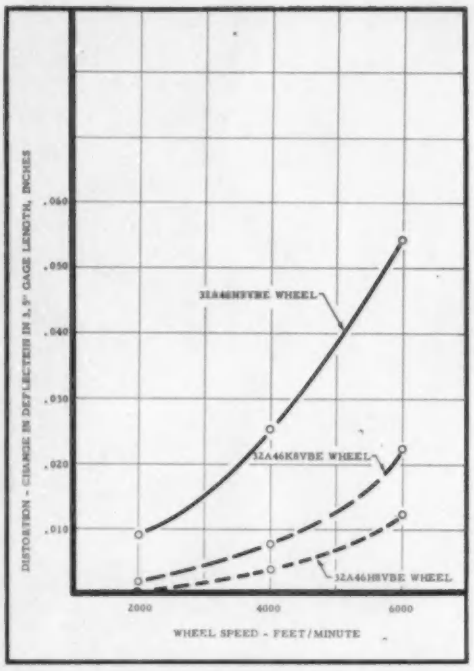
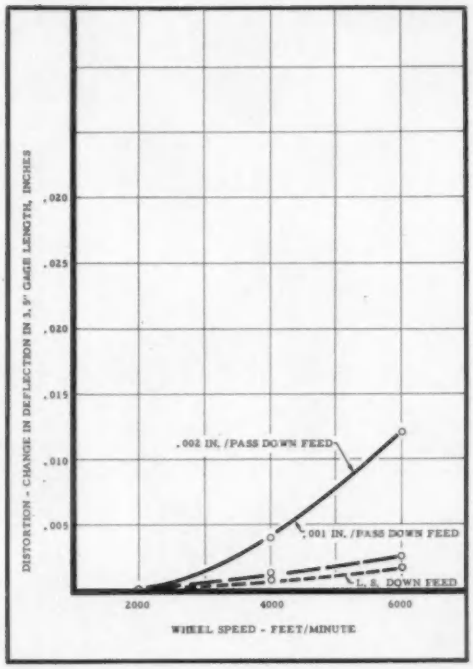
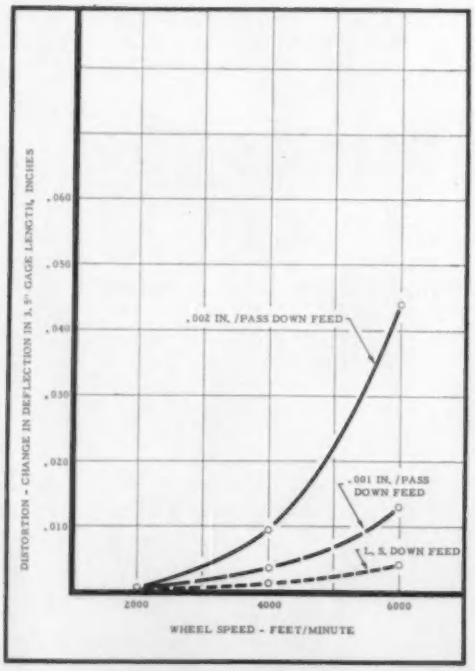


Fig. 2 — Effect of wheel grade on distortion. Test conditions: down feed — 0.002 in./pass; cross feed — 0.040 in./pass; table speed — 60 fpm; depth of grind — 0.010 in.; grinding fluid — soluble oil (40:1).

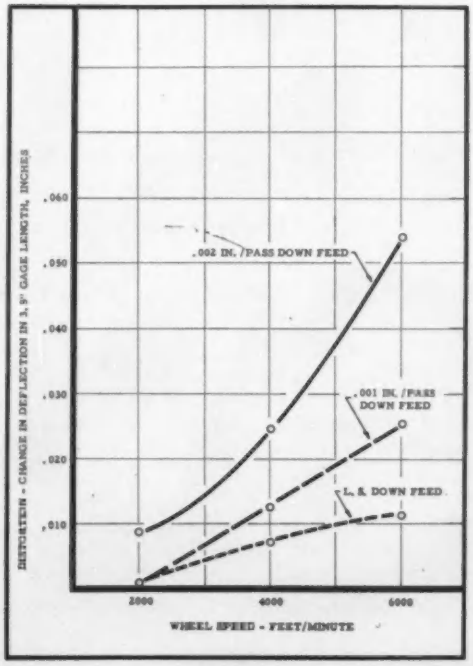


H WHEEL



K WHEEL

Fig. 3 — Effect of down feed on distortion. Test conditions: cross feed — 0.040 in./pass; table speed — 60 fpm; depth of grind — 0.010 in.; grinding fluid — soluble oil (40:1).



N WHEEL

specimens used in the distortion studies. The thickness was such that all specimens were 0.660 in. thick after testing.

The strips for the test specimens were cut from a forged SAE 4340 steel bar and heat treated to a hardness of 52 R_c. After heat treatment, the strips were carefully ground to finish size using a low stress grinding procedure.

Grinding and milling tests were performed on one side of the specimen only, leaving the bottom surface unmarked for gaging purposes.

To investigate the nature and magnitude of the residual surface layer stress which cause workpiece distortion the worked surface was progressively etched and changes in deflection of the workpiece noted. The change in deflection versus depth of stock removed data was then used to calculate the residual stress at any depth below the test surface.

SURFACE GRINDING DISTORTION

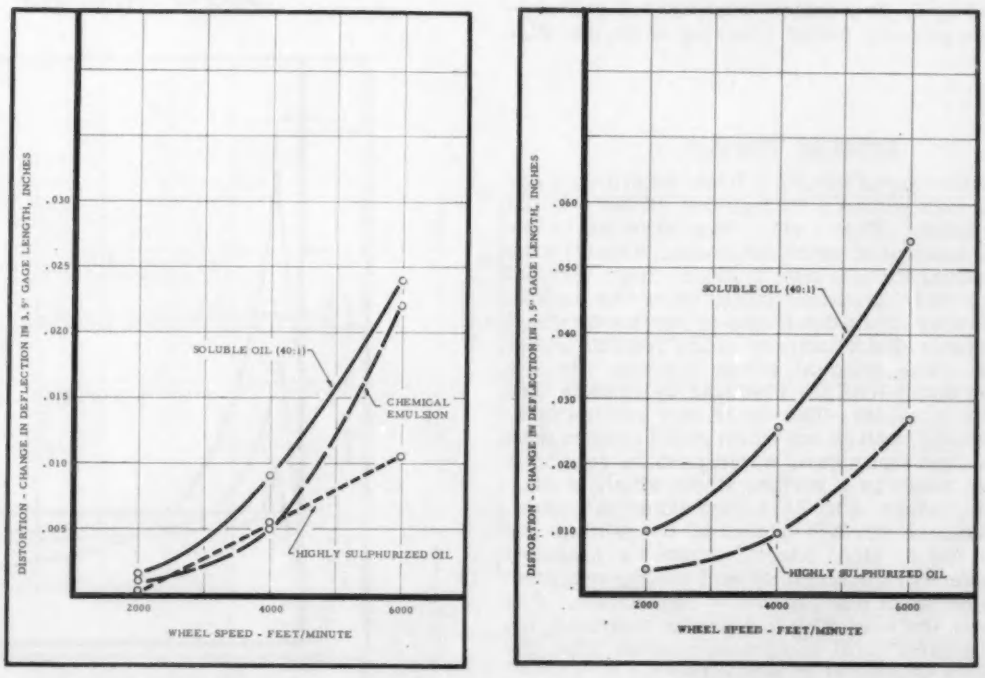
Distortion is closely related to wheel speed. At low wheel speeds, 2000 fpm say, distortion is at a minimum for any given set of grinding conditions. At a wheel speed of 6000 fpm, which is conventional for most production grinders, the greatest distortion is observed.

EFFECT OF WHEEL GRADE — As the hardness of the grinding wheel is increased the distortion also increases. This effect is illustrated in Fig. 2. With an N (hard grade) wheel turning at 6000 fpm the change in flatness of the test specimen is 0.054 in. This compares to 0.002 in. for the K (medium grade) wheel and 0.012 in. for the H (soft grade) wheel.

EFFECT OF DOWN FEED — Coarseness of down feed also produces a great change in distortion. Fig. 3 shows this effect for the different wheel grades. In each case the greatest distortion is noted when a down feed of 0.002 in. per pass was used. In fact the distortion at 0.002 in. per pass was more than twice that of 0.001 in. per pass case at a wheel speed of 6000 fpm. The L.S. (Low Stress) down feed procedure, which produced the least distortion in each case, was as follows:

0.001 in. per pass to the last 0.002 in. of depth
2 passes of 0.0005 in. per pass
1 pass each at 0.0004 in., 0.0003 in., and 0.0002 in.
No sparkout

EFFECT OF GRINDING FLUID — The highly sulpherized oil produces far less distortion than a water



K WHEEL N WHEEL

Fig. 4 — Effect of grinding fluid. Test conditions: down feed — 0.002 in./pass; cross feed — 0.040 in./pass; table speed — 60 fpm; depth of grind — 0.010 in.

Reduce distortion from grinding and milling operations

. . . continued

base grinding fluid, such as a soluble oil or a chemical emulsion. Fig. 4 shows this for two different wheel grades.

EFFECT OF CROSS FEED AND TABLE SPEED — No significant change in distortion during surface grinding occurs by varying these factors, as compared to the effect of other grinding variables. The problem of controlling distortion during surface grinding can be overcome by carefully selecting the grinding conditions. When the L.S. down feed is used together with a highly desulpherized oil as a grinding fluid, then distortion is a minimum at all wheel speeds for the different wheel grades.

FACE MILLING DISTORTION

The distortion studies in milling were made using a 4 in. diameter single tooth face mill with a clamped in ⅝ in. square carbide tipped tool bit. The effects of sharpness of cutter, cutting speed, depth of cut and cutting fluid were studied. The results are presented in Fig. 5. It is evident that the cutter sharpness is the primary factor affecting workpiece distortion.

RESIDUAL STRESSES

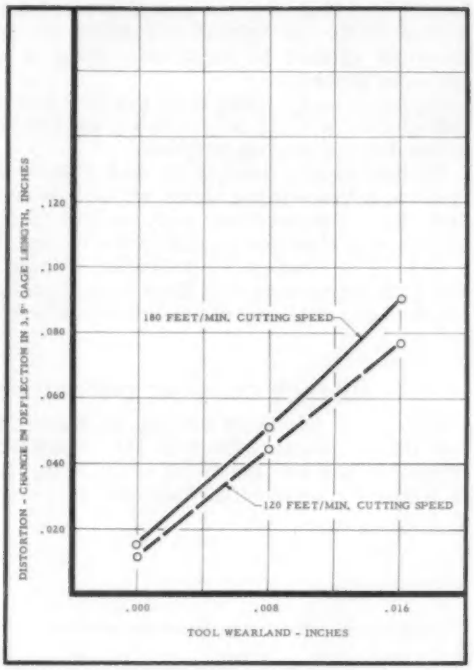
The highest stress resulting from the grinding operation occurs within a thousandth of the original ground surface. That a close correlation exists between the amount of distortion produced and the induced residual stress is seen in Fig. 6. Here, residual stress is plotted for various depths below the surface. As the severity of the down feed is increased (which means greater distortion), so is the residual stress increased. The residual stress analyses indicate that large distortions are produced by stresses that are tensile in nature. The use of very gentle grinding conditions, such as low wheel speed coupled with L.S. down feed techniques, which produce very little distortion, result in a surface stress which is compressive in nature. Fig. 7 is a good example of this.

The residual stresses produced by milling are plotted in Fig. 8. Here, a tensile stress was produced at the surface of the specimen and became compressive at a depth of 0.001 in. below the surface. The duller tools, the ones with the greater wearland, induced a greater total compressive stress than the sharp cutter with 0.000 in. wearland.

Besides being important in producing distortion it has also been found that residual stresses adversely affect fatigue properties of the material.

To Order Paper No. 304L . . . from which material for this article was drawn, see p. 6.

Fig. 5 — Face milling distortion. The



EFFECT OF CUTTING SPEED

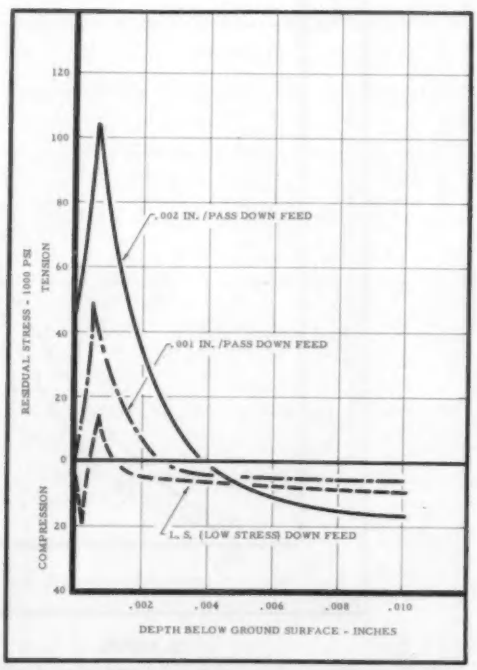
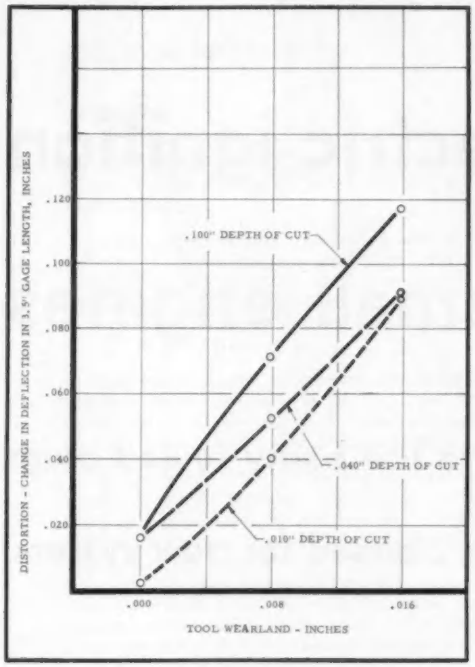
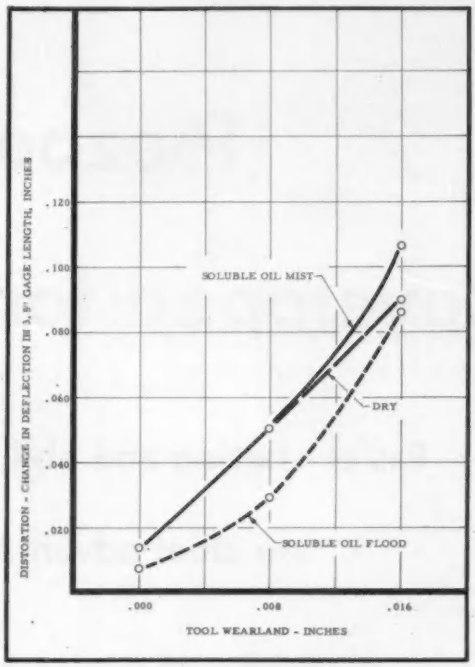


Fig. 6 — Residual stress in ground surface. The area under the curve for each stress distribution pattern is a measure of the bulk stress induced under the surface layer of the workpiece. Residual stress is highest in cases where distortion was greatest.

curves show that cutting tool sharpness is the prime factor in determining distortion.



EFFECT OF DEPTH OF CUT



EFFECT OF CUTTING FLUID

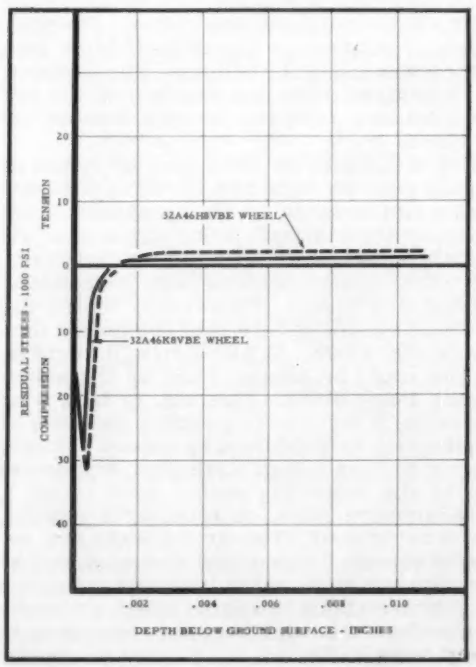


Fig. 7 — Gentle grinding conditions, which produce very little distortion, result in a surface stress which is compressive in nature. Large distortions are produced by tensile stresses.

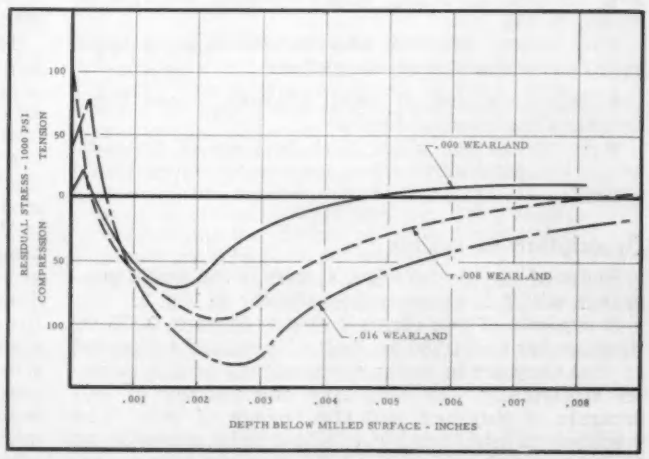


Fig. 8 — Residual stress in milled surface. The tools with the greater wearland produce the greatest amount of residual stress and also the greatest distortion.

Piezoelectric ignition developed for small engines

Easier starting and ability to fire badly fouled plugs are chief advantages claimed for new system.

Based on paper by

Edwin Crankshaw and R. Arnold

Cleveland Graphite Bronze Division, Clevite Corp.

A PIEZOELECTRIC ignition system has been developed for small, single-cylinder engines, as shown in Fig. 1.

This system provides two important advantages over conventional ignition systems:

- Easier starting of small engines, where hand cranking is almost universal.
- Ability to fire plugs that, because of deposits, would be inoperative when used with conventional systems.

Description of system

Heart of the piezoelectric system is the spark generator, which is shown schematically in Fig. 2.

It consists of two ceramic elements, each 0.375 in. in diameter and 0.750 in. long. These are supported so that they are in series mechanically and in parallel electrically. In this way the voltage of one ceramic is obtained, but the energy of two. The mechanical input force *F*, of about 80 lb, is multiplied 15 times by the leverage system shown. This system, using a displacement of 0.120 in. at the end of the input lever, develops 16,000–19,000 v, with an energy level of about 0.015 joules at 18,000 v. The same device is shown exploded in Fig. 3. This model generator, or "Spark Pump," occupies about 3½ cu in., weighs about 8 oz, and is the present production model. The ceramic elements in tandem are sealed within the central insulator block, and the block is supported by the stamped steel housing. Compression of the ceramics is obtained by the actuating lever and its force multiplication system. Reaction to this force is supplied by the self-adjusting load screw at the lower end of the housing. The electrical lead, which is taken off at the junction of the two ceramic elements, is provided for by a boss on the insulator block.

The pump is installed on the engine by means of the mounting plate provided and the actuating lever is operated by an eccentric on the crankshaft or on an extension of the camshaft if the engine is of the four-stroke type. Fig. 4 shows an assembled pump.

As with other ignition systems, the piezoelectric method requires a means of accurately timing the spark so that it occurs uniformly at the proper time in the combustion cycle. At first glance, it might be assumed this could be accomplished by the action of the Spark Pump alone. This has, in fact, been done. However, it requires very sudden stressing of the ceramics, such as is obtained by impact. Impact systems seem to have a high noise level, and excessive wear of the impacting parts. As a result, a gradual compressive force, obtained by a rotating eccentric, is being used. This action leads to a relatively slow voltage buildup, and the spark occurs when the voltage is sufficient to jump the gap at the plug. Due to variations in engine speed, or conditions within the combustion chamber, variations in timing may occur.

To correct this situation, a timing switch must be used. To some degree, this switch corresponds to the distributor used in conventional ignition systems on multicylinder engines. But, on the other

How piezoelectricity works

PIEZOELECTRICITY is an electrical charge due to the change of stress within a crystalline material.

In the piezoelectric ignition system, the crystalline material used is a lead-zirconate-titanate ceramic called PZT, which was specially developed to have a high piezoelectric effect, as well as great strength and stiffness, and excellent dielectric properties.

Such ceramics are composed of a multitude of crystals in random orientation. When poled by a strong d-c field, they behave similar to a single crystal, and become piezoelectric.

Fig. A shows how piezoelectric materials are used. A small cylinder, supported at the bottom, is compressed by a force *F*. As F is increased, a voltage potential is developed between the two ends, and is stored within the element because it is capacitive. When *F* is released, the ceramic returns to its original size, and the charge is reduced to zero. Now, if a spark gap is connected to the two ends of the same ceramic, and it is again stressed by means of force *F*, as the voltage is developed, a spark occurs across the gap, and the voltage differential no longer exists. If the force *F* is now released, a second spark occurs as the ceramic returns to its original size.

In the first case, essentially all of the mechanical energy used in compressing the ceramic is given back when the force is released. In the second case, somewhat less mechanical energy is returned, since some of it has been converted and used as electrical energy in jumping the spark gap.

Obviously, other modes of inducing stress may be used to obtain a voltage output. A cantilever beam may be bent, plates may be sheared, or rings expanded. In the ignition device, however, compression has been used because, in this way, high stresses, and hence high voltages, can be developed without mechanical failure.

There is, of course, a definite relationship between the stress applied and the voltage obtained.

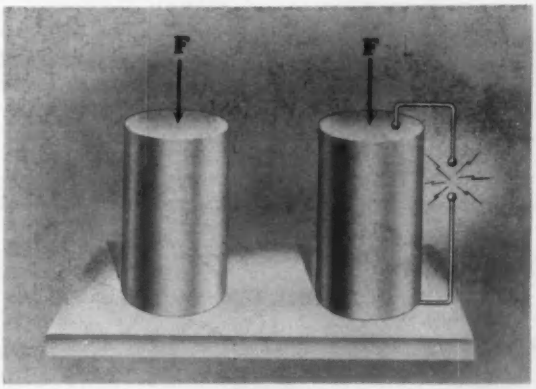


Fig. A — Diagrammatic presentation showing how piezoelectric force is developed.

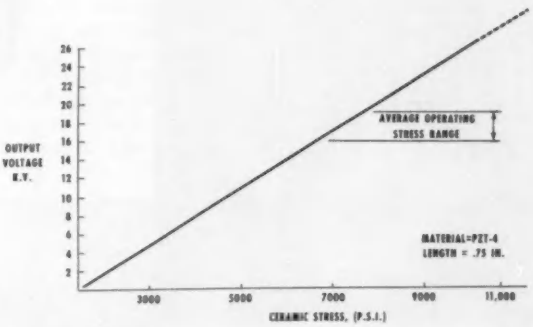


Fig. B — Voltage developed by ceramic elements under stress.

Fig. B shows this, and also shows the average operating stress now being used in the ignition device. The physical properties of the ceramic would indicate that much higher stress levels are possible. However, in addition to a safety factor, allowance has been made for the fact that, in production assemblies, the load may not be uniformly applied. At the stress level indicated, tests have not yet been run long enough to determine the number of cycles required for failure, but it must exceed 100 million.

hand, there are differences. In the distributor, the timing of the high voltage can be controlled by the breaker points in the low-voltage circuit. In the piezoelectric system, there is no primary, or low voltage, system. Thus the switch must be designed to handle the incoming high voltage pulses with a minimum of energy loss.

To provide long paths to ground, and as an aid in close control of timing, a large-diameter switch would be desirable. But in order to fit into existing engine profiles, a compromise with size is necessary. Whatever the size or design, the switch material should have excellent electrical properties. The material now being used is a glass-filled alkyd polyester having a volume resistivity of 10^{14} ohm-cm. This may be compared to the material used in distributor caps, which is on the order of 10^{13} ohm-cm. From a leakage standpoint, the critical part of the

Fig. 1 — **Piezoelectric ignition system** installed on small, single-cylinder engine.

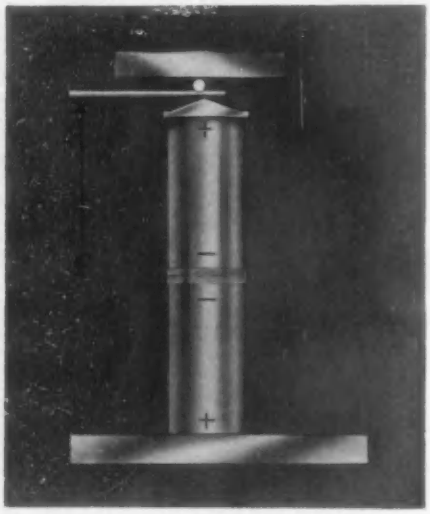


Fig. 2 — **Schematic diagram** showing basic design of spark generator.

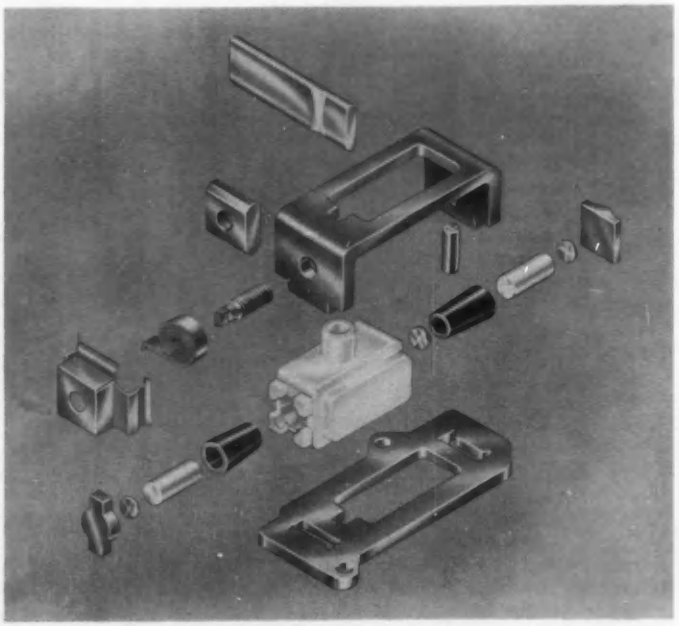


Fig. 3 — **Exploded view** of spark generator.

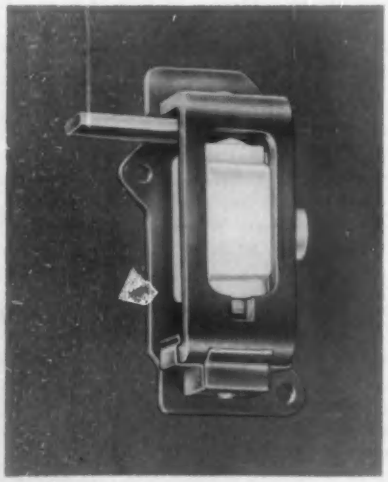


Fig. 4 — **Assembled pump.**

Piezoelectric ignition

. . . continued

switch is at the site of the incoming current. While other switch parts could be made of less exotic material, the polyester is being used for all parts.

As with the automotive distributor, the presence of high voltage makes the switch vulnerable to internal shorting due to conductive paths caused by moisture, or a combination of dust and moisture. This suggests a switch which is hermetically sealed. However, sealing presents another problem, since it is not compatible with the required low cost. Furthermore, if the sealed switch becomes inoperative for any reason, it would require complete replacement.

One alternative is to resort to a simple unsealed switch, so that if and when internal shorting takes place, the switch may easily be disassembled for cleaning. Switches of both types are under development and, while field testing has not been completed, preliminary results indicate the problem may not be as severe as predicted above. Fig. 5 shows the construction of a typical closed switch. In this design the rotor is keyed to the crankshaft and is the only moving part. It carries the electrical shunt which makes contact with the electrodes molded in the switch base. The base is provided with a cover, and both have felt seals and plastic wafers which act as seal retainers. The cover is secured to the base by the use of epoxy resin, and the same agent is used in securing the seal retainers in place.

Fig. 6 shows the two components of an open-type switch. Simplicity is the key word of this design, with perhaps some compromise in performance where environmental conditions are severe. Here, the rotating section which carries the shunt is mounted in the flywheel. The other section, which carries the stationary contact points, is mounted to the engine block. Switching takes place as the rotating member passes and bridges the contact points in the stationary member. To obtain some degree of closure, the inside diameters of both parts are provided with felt rings.

While the switch adds to the space required by the system, and to the overall cost, it plays a very useful role. First, it provides a very high rate of voltage rise. This is due to the fact that the circuit connecting the Spark Pump and the spark plug is made by one of the rotating elements of the switch. Further, there is no time limit imposed on this circuitry due to magnetic hysteresis. The high rate of voltage rise, which has been measured as 10 millimicro sec to 10,000 v, is useful in firing spark plugs which would be considered fouled if used with other ignition systems.

Second, the switch provides a simple method of spark advance or retard. On engines manufactured on a price basis, this control would be manual; in equipment built for the deluxe trade, the control could be automatic.

Lastly, the switch plays a necessary part in certain engine configurations by grounding out any unwanted voltage pulses. These develop due to the cyclic relaxation of the ceramic, and must be dissipated before the element will again develop voltage on being compressed.

Fig. 1 shows a complete PZT ignition system installed on a small, single-cylinder engine. Here, the pump is driven by an extension of the camshaft, and the switch is mounted on the engine block so that it has some freedom of movement for advance and retard. The high voltage wire connecting the Spark Pump to the switch, and the switch to the plug, are also shown. The high point of the actuating eccentric and the rotor shunt in the switch are, of course, located for firing the plug at the desired time. As full voltage is developed at the Spark Pump, the circuit to the plug is completed, and the plug fires. It is difficult to imagine an ignition system with fewer components, or one which operates on a more straightforward basis. (It is to be noted that this installation is one of adaptation rather than integration, since the engine was designed for magneto ignition and required modification for this use.)

Characteristics of PZT system

Fig. 7 shows the relationship between voltage and energy for the particular elements now used in the Spark Pump. This is a rather fundamental curve, for it points out that, for a given voltage, the energy available is fixed by the dimensions of the piezoelectric elements. If more energy is desired, the diameter of the elements must be increased, or the

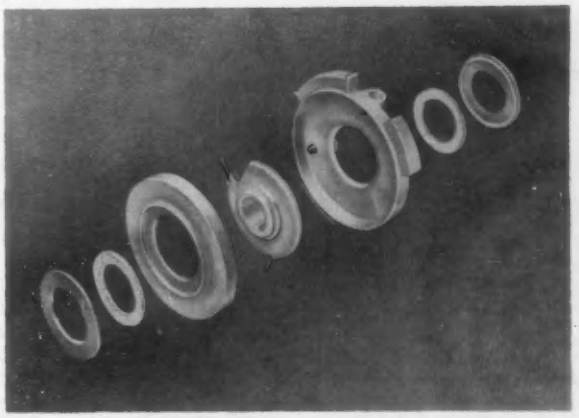


Fig. 5 — **Exploded view** of typical closed switch.

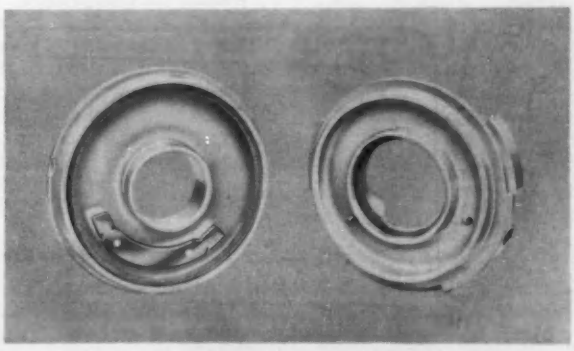


Fig. 6 — **Components** of open-type switch.

Piezoelectric ignition

. . . continued

system operated at a higher stress level. The curve also serves to determine the broad limits on the amount of energy available from this source. For igniter systems requiring energies in the range of 2–4 joules, present piezoelectric materials cannot be used without resorting to a system which is comparatively large, heavy, and demanding of large mechanical input. Using PZT-4 ceramic material, approximately 40% of the mechanical input is transformed to electrical energy; the remainder is returned to the input system.

One of the principal advantages of the PZT ignition system is that a spark is obtained at very low engine rpm. This, of course, leads to easier starting of small engines, where hand cranking is almost universal. Fig. 8 shows the voltage versus crankshaft rpm for the PZT system, and for the small magneto which it replaces.

Normal hand-cranking speed is considered to be about 300 rpm. Note that the PZT unit develops its full rated voltage at this speed, and even if it were driven by the camshaft the voltage drop-off would be exceedingly small. The magneto, however, at 300 rpm has dropped to about 60% of its rated voltage. While this reduced voltage is ample to maintain engine operation after starting, it may not be enough to provide easy starting unless other conditions are ideal.

On larger engines, where size, weight, and cost are less restricted, an impulse coupling may be used to improve the starting characteristics of the magneto system. Obviously, such couplings are not necessary for use with the PZT system.

Another important advantage of the PZT ignition system is its ability to successfully fire plugs which, because of deposits, would be inoperative when used with conventional ignition systems. In multicylinder engines incipient spark-plug fouling may not be readily apparent. However, in small engines, particularly of the two-stroke type, spark-plug fouling is high on the list of operational problems. In running these engines, the superiority of the PZT ignition as regards spark-plug life has been demonstrated repeatedly. With one make of engine, for example, test data indicates spark-plug life may be doubled.

To simulate plug fouling, both the PZT and magneto system have been operated using decreasing values of shunt resistance across the plug. As shown in Fig. 9, with plugs having high resistance, the two systems are equivalent. However, as the resistance figure is lowered, the voltage available from the magneto system begins to decrease, until starting, and finally even running, would be impossible. On the other hand, the voltage output of the PZT system shows only a slight drop-off, even at a spark-plug resistance of only 10,000 ohms.

The explanation for this sizeable difference lies in the unusually high rate of voltage rise obtained from the Spark Pump and switch combination. The PZT elements, when stressed, may be compared to a charged capacitor. As the switch completes the circuit between this capacitor and the plug, the voltage rise time is much higher than other ignition systems that have been measured. As mentioned earlier, rise times of 10 millimicro sec to 10,000 v have been obtained. Corresponding voltages with a magneto system require 30–35 microsec.

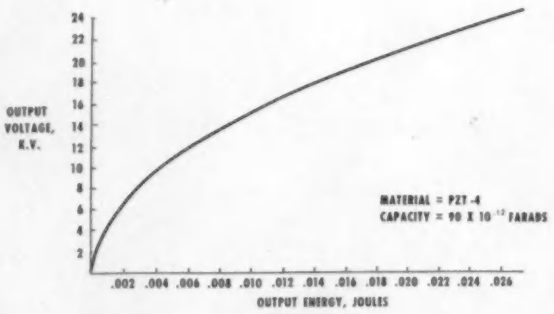


Fig. 7 — **Ceramic element energy** and voltage characteristics.

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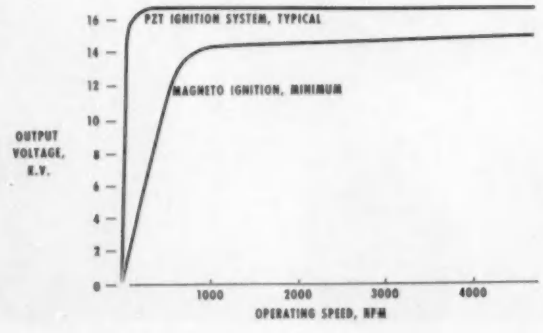

Fig. 8 — **Low-speed** output voltages.

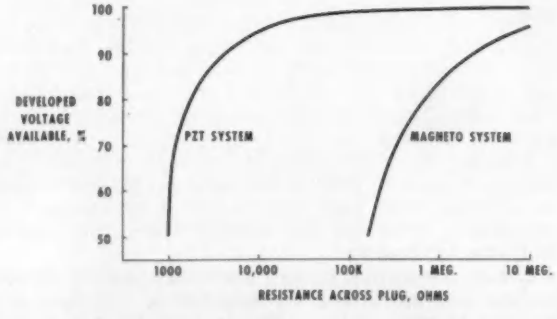

Fig. 9 — **Effect of** shunt resistance across spark plugs.

Computers can be the slaves of management

THE ACCOMPANYING ARTICLE is based on a panel discussion on, "Computers & Mathematics — Management's Master or Slave?" In addition to L. (Bud) Tellander, panel secretary, who is the author of this article, the panel consisted of:

Chairman:

JAMES C. HETRICK, Arthur D. Little, Inc. (Mathematician and Operations Expert, Company X)

Panel Members:

HARRY GEORGE, Martin Co., (Vice-President of Manufacturing, Company X)
HARRY R. BALL, Whirlpool Corp. (Director of Planning, Company X)
JOHN CAMMARATA, Arma Corp. (Director of Manufacturing Engineering, Company X)
FLOYD KELLY, Temco Electronic & Missile Corp. (Director of Traffic & Purchasing, Company X)
BURTON I. MAYNARD, Douglas Aircraft Co. (Comptroller, Company X)
GORDON F. PEARSON, North American Aviation, Inc. (Production Manager, Company X)

The program concerned the operation of a hypothetical company, with the panel acting as a problem-solving group for the company. Thus, the above listing gives their titles as officers in Company X, as well as their actual company affiliations.

Management must continue to use judgment, policy decisions, and experience to run its business . . . but computers can be management's slaves, providing quickly, factual, unbiased answers to questions that management poses.

Based on panel report by

L. (Bud) Tellander
Whirlpool Corp.

THE mathematical modeling technique — or the mathematical programing of a problem on a high-speed computer — can be of great assistance to management in making major decisions of many kinds. It can provide management with optimum solutions to certain problems more quickly and accurately than can normally be accomplished through manual analysis.

To illustrate how this can be done, the principles of mathematical programing will be applied to a practical, through hypothetical case problem. Due to a lack of space, restrictions (or assumptions) are introduced that normally need not be imposed in a real problem.

The problem of Company X

Company X consists of four manufacturing divisions, located in Omaha, Jacksonville, Los Angeles, and in Pittsburgh, which is also the home office.

The company is at present involved in the manufacture of a medium-sized twin-engine airplane at its Pittsburgh plant, while making the engines for this airplane at the Jacksonville plant. The Omaha plant now manufactures factional horsepower motors, and the Los Angeles plant is on a standby basis, with a bare minimum of engineering and direct labor personnel.

Management wishes to bid on the Exterminator, a ground-to-surface missile with a 100-mile range, and it is necessary to plan integration of its manufacture with present operations. This involves decisions of where to engineer, where to manufacture, what to buy, how to allocate present production, and and the like. Such problems can be approached through the use of the mathematical modeling technique.

Possible methods of manufacture

There are numerous possible methods of manufacturing the Exterminator, when present production products are taken into consideration. Obviously, these involve the possibilities of building the mis-

sile at each of the four plants in total, or of building any of the seven parts in any of the four plants plus the possibility of building complete versions or any portion of their present products in the four plants of Company X.

To assist in the solution of this massive problem, one can lay out in matrix form the possibilities of manufacturing the Exterminator plus the company's present products. But such a mathematical model would require a matrix containing at least 68 equations in 180 variables, and in all probability additional equations of restrictions would be required for proper solution. This problem can be solved on present-day computation equipment. Unfortunately, Company X does not have equipment that would solve problems of this size: therefore it is necessary to go outside for computer time.

The cost of a solution on a computer is approximately the cube of the size of the matrix. As a result, the cost of gathering the required information plus the cost of the solution become a matter of considerable concern.

Management believes the problem was presented too broadly. So, it has set up a few specific requirements to be used as assumptions in developing the data that will finally be fed into the computer. Management says:

- Exterminator research and development stage (10 missiles) must be done at Pittsburgh.
- Exterminator is not seven but but four basic units; because logical assemblies exist and give savings when done in a single plant.
- Any one plant must manufacture an entire unit of present products or no part of it. Reason: It is unprofitable to tranship parts, such as airframes, engines, and fractional horsepower motors, from one plant to another.
- A uniform production rate of present-production parts must be maintained throughout the Exterminator contract.
- The ground support equipment for the Exterminator will be built only in the production phase. (The production phase will be preceded by the research and development phases and the preproduction phase.)
- Only engineering manpower will be considered as limiting because direct labor is relatively easy to hire and train.
- Preproduction phase (50 missiles) will be accomplished without transhipment because of limited volume.

Construction of mathematical model

The possible assignment of production is described in matrix form in Table 1. Note that each term of the matrix refers to one possible method of manufacture. For example, "X_1" indicates the number of complete missiles built at Pittsburgh in the preproduction phase; "X_{12}" the number of units of assembly 1 built at Pittsburgh in the production phase, etc. The equations to describe Company X's operations and restrictions are derived from Table I.

Quantity requirements

Missile requirements are the sum of complete Exterminators in the preproduction phase, thus:

$$X_1 + X_2 + X_3 = 50$$

The sum of the numbers of each part equals the total requirement in the production phase:

$$X_{12} + X_{13} + X_{14} + X_{15} = 2000$$
$$X_{16} + X_{17} + X_{18} + X_{19} = 2000$$
$$X_{20} + X_{21} + X_{22} = 2000$$
$$X_{23} + X_{24} = 2000$$

Preproduction requirements

Since management had not prescribed the minimum demand for airframes, engines, or motors, the sums of this production did not need to be stated. However, a ratio of two engines per airframe had to be observed, described as:

$$X_6 + X_7 + X_8 + X_9 = 2(X_4 + X_5)$$

and:

$$X_{27} + X_{28} + X_{29} + X_{30} = 2(X_{25} + X_{26})$$

and for ground support equipment:

$$X_{33} + X_{34} + X_{35} + X_{36} = 100 \text{ (production phase)}$$

Shipment of assemblies between plants

Economies can usually be achieved through purchasing in certain parts of the country (including savings in different freight possibilities). Consequently, it is necessary to allow the mathematical model flexibility of considering transhipment of assemblies in the production phase between plants. To describe this mathematically, it is necessary to introduce further identifications for use in equations. The restrictions defined by these identities are as follows:

For Assembly 1

Final assembly at Pittsburgh = (Assembly No. 1 produced at Pittsburgh) – (Assembly No. 1 shipped from Pittsburgh) + (Assembly No. 1 shipped to Pittsburgh)

Final assembly at Omaha — Similar to above

Assembly No. 1 produced at Los Angeles = (Assembly No. 1 shipped from Los Angeles to Pittsburgh) + (Assembly No. 1 shipped from Los Angeles to Omaha)

Similar balances on Assembly 2 and Part 4 give an additional seven equations.

Manpower restrictions

As noted in assumption 6 of the seven management assumptions, engineering manpower seems to be the only limiting factor. We must, therefore, identify the engineering possibilities as being simply the sum of the manpower requirements for each plant for each product (assembly). Obviously, the manpower requirement must be equal to or less than the total engineering manpower available. Data collected previously provided the number of man-hours per assembly or unit. Consequently, the manpower requirements can be described as follows:

$$1213X_1 + 42X_4 + 106X_6 + 650X_3 + X_{53} =$$
Pittsburgh engineering man-hours available

(plus six more equations)

Here, the coefficients represent engineering man-hours per unit produced. The term involving "X_3" shows that, to produce the missile, Jacksonville must borrow engineering manpower from Pittsburgh, and

Table 1 — Possible Assignment of Production to Plants

	Preproduction Phase				Production Phase			
	Pittsburgh	Omaha	Los Angeles	Jacksonville	Pittsburgh	Omaha	Los Angeles	Jacksonville
Exterminator	X_1	X_2		X_3				
Assembly 1					X_{12}	X_{13}	X_{14}	X_{15}
Assembly 2					X_{16}	X_{17}	X_{18}	X_{19}
Part 4					X_{20}	X_{21}		X_{22}
Final Assembly					X_{23}	X_{24}		
Air Frames	X_4		X_5		X_{25}		X_{26}	
Engines	X_6	X_7	X_8	X_9	X_{27}	X_{28}	X_{29}	X_{30}
Motors		X_{10}	X_{11}			X_{31}	X_{32}	
Ground Support Equipment					X_{33}	X_{34}	X_{35}	X_{36}

"X_{53}" is introduced to balance the equation, if not all the manpower available is required.

Support of small business

The contracting authority requires that 20% of the contract amount be purchased from small businesses. This can be introduced by the restriction that:

Sum of terms [(value of unit × 20%) × (number of units)] be equal to or less than sum of terms [(number of units) × (purchased component of unit)]

Reduction of problem

The restrictions on the problem have now been completely stated (with the management assumptions) and can be solved in this form. However, to reduce the size of the problem and to lower the cost of computing, we may manipulate the equations in three ways, namely, by:

- Elimination of redundant expressions.
- Use of constant relationships between variables.
- Elimination to establish a basis.

Taking advantage of these three possibilities reduces the problem to 24 necessary equations.

Solution of the problem

The next step is to solve the problem of where to make the Exterminator (and the company's present products) on the computer. This particular problem, condensed as already described, took about 28 min for solution on the demonstration computer, after all the information was punched on cards.

Examination of the computer's "print out" shows that it is most profitable if Company X manufactures all their present products where they are now being manufactured, and includes the Exterminator production totally in the Pittsburgh plant, for all phases.

However, this solution, while correct for the problem as stated, is impossible because it requires more direct labor personnel to be in the Pittsburgh plant than the plant can possibly hold. This shows that management assumption No. 6 was erroneous.

Logical as it may have seemed, engineering manpower under these circumstances is not the limiting manpower factor.

It is a relatively simple matter to introduce a new variable that will describe direct labor manpower restrictions (maximums) in each plant. When this is done, the problem can be rerun, giving the following solution:

Preproduction phase:

50 complete Exterminators to be built at Pittsburgh

Production phase:

1350 Exterminator Assembly 1's to be built at Pittsburgh
650 Exterminator Assembly 1's to be built at Los Angeles
1350 Exterminator Assembly 2's to be built at Pittsburgh
650 Exterminator Assembly 2's to be built at Los Angeles
1350 Exterminator Part 4's to be built at Pittsburgh
650 Exterminator Part 4's to be built at Omaha
1350 Exterminator Final Assemblies to be made at Pittsburgh
650 Exterminator Final Assemblies to be made at Omaha

All 100 ground support units to be made at Omaha.

The solution also indicates a shift of present production as follows:

- Engines now being produced totally at Jacksonville should be produced at both Jacksonville and Pittsburgh (approximately 50–50).
- Airframes now being built at Pittsburgh must be built in Pittsburgh and Los Angeles (about 40% in Pittsburgh and 60% in Los Angeles).
- Fractional horsepower motors now being built in Omaha must be built in Omaha and Los Angeles (about 30% in Los Angeles and 70% in Omaha).

Crashworthiness

improves survivability in light aircraft

With proper design, it would not require a "miracle" to be able to walk away from a crash.

Ten major recommendations for reducing crash injuries and fatalities are:

1. Design forward fuselage and cabin structures to resist crash loads as well as flight and landing loads.
2. Design structures to absorb energy by progressive collapse.
3. Design tubular structure to bend and fail outwardly . . . away from the occupants.
4. Locate the pilot and passenger seats as far behind the wing as possible.
5. Locate fuel tanks in, or on, the wings — not between the firewall and the instrument panel.
6. Provide space between the instrument panel and the forward section to permit forward displacement of the panel and instrument cases.
7. Design the instrument panel to be free of sharp rigid edges in range of the pilot's head.
8. Fabricate the instrument panel of ductile material or use an energy absorbing shield on the panel face.
9. Mount instrument cases on shear pins or as low on the panel as possible.
10. Provide shoulder harness, safety belts, seats and seat anchorages of sufficient strength to resist failure up to the point of cabin collapse.

Based on paper by

Karl H. Bergey

Piper Aircraft Corp.

A NUMBER of new agricultural aircraft have been designed in the past decade . . . all influenced to some extent by crashworthiness considerations. Although it is too early to draw firm conclusions, the trend in these aircraft is toward lower fatality rates. These new planes suffered one accident for each 4000 hr of flying in 1959, and one fatality for each 90,000 hr. By comparison, the accident rate for all agricultural flying in that year was one for each 3000 hr of flying. The fatality rate was one death for each 16,000 hr. The total number of aerial application hours was 880,000 hr.

Typical of the new design is the Snow, shown in Fig. 1. These planes use a low-wing configuration with the pilot located above and behind the hopper in a well-protected cockpit. Evidence of the usefulness of crashworthiness concepts appears in Fig. 2. The wreckage is that of an airplane which hit the ground after coming in contact with telephone lines. The pilot, who was wearing a safety belt, a shoulder harness, and a hard hat, suffered only minor injuries and walked away from the crash.

In any consideration of crashworthiness, the two most important factors to bear in mind are:

1. Accidents in which the cabin of the aircraft is not collapsed or disintegrated should be survivable.

2. Head injuries account for nearly 80% of the deaths in aircraft accidents.

In connection with the first item, the following are specific recommendations which should be useful:

- Provide as much clear space as practical between the engine and the firewall. Here a short and

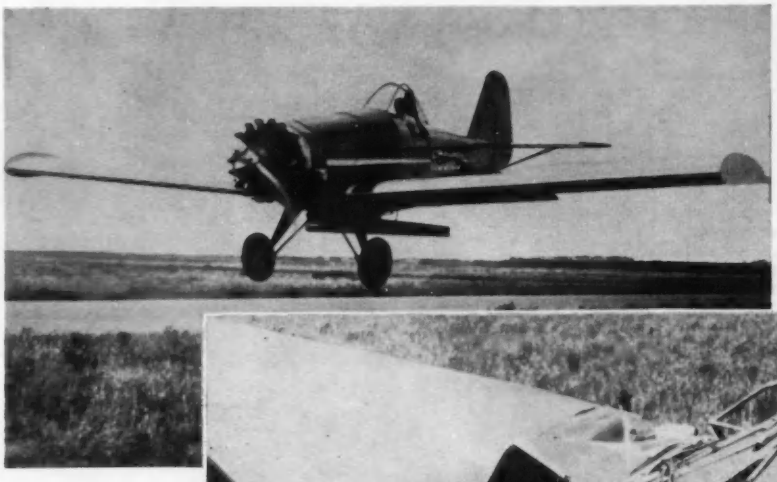

Fig. 1 — **THE SNOW — A NEW AGRICULTURAL PLANE,** is typical of a whole group of newly designed aircraft which utilize many crashworthiness concepts. These planes have had about the same accident rate as other designs but the fatality rate has been reduced.

Fig. 2 — **THE PILOT WALKED AWAY FROM THIS WRECK** . . . thanks to many safety features. Note the relatively intact turn-over structure, the outward bending of the cockpit longerons away from the pilot and the indented soft metal pad at the top of the instrument panel.

lightweight powerplant such as the centrifugal impeller turboprop has a real advantage. It can be placed well forward without compromising the aircraft center of gravity.

- Carry the body bending loads over the top of the cabin through a husky compression-tension member running up the center of the windshield.
- Provide door locks which make the door an integral part of the cabin structure when closed.
- Place the wing low on the fuselage where it can protect the cabin and absorb energy in low angle impacts.
- Avoid placing heavy masses above or behind the cabin structure.
- The fuel should be located as far outboard on the wings as possible to minimize the danger of fire. This is especially important since the structural door is likely to impede rapid exit after a crash. The Cessna 310 and the Piper Apache use this approach.

Protection from head injuries is probably subject to more compromises than any other item of crash survival. The obvious answer is to use both high impact safety belts and shoulder harnesses. Unfortunately, the flying public, while accepting the safety belt, has shown a monumental indifference to the shoulder harness. Two approaches might be useful here. The first would be widespread publicity and advertising similar to that used to popularize safety belts for automobiles. To make this effective, some modification of the polite fiction that airplanes do not crash would be required. The second approach would be universal provision for a simple cross-chest strap such as that available on the Beach Bonanza or the G. T. Saab automobile.

In the absence of shoulder harnesses the instrument panel should be delethalized. Recommendations for crashworthiness place the gyro instruments low — away from the ballistic range of the pilot's head. This requires compromise of the standard panel recommendations which place the gyro instruments high in front of the pilot.

One of the most practical solutions to this problem is the use of a ductile shield over the panel — backed by an energy-absorbing foam. A large ductile roll over the top of the panel will provide additional protection.

Knobs are hard to shield in any case. The instrument designer can help by developing a directional gyro without a forward-protruding caging knob.

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from which material for this article was drawn, see p. 6.

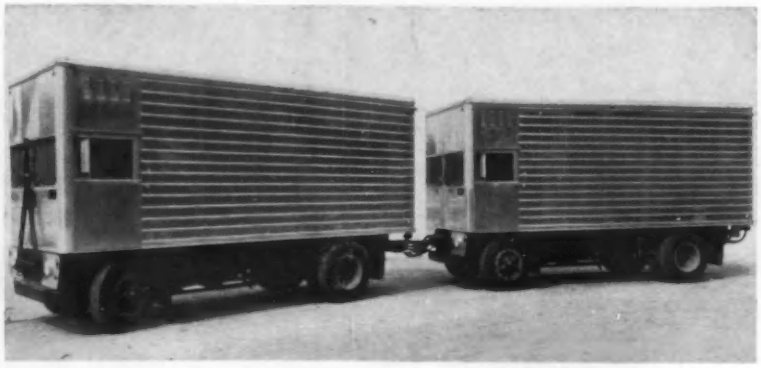

Fig. 1 — Each Wolfwagon unit is self-propelled, but requires only one driver when operated in pairs or in a train. Driver compartment is tucked into corner of van body.

The Wolfwagon

something new in truck design

Based on paper by

L. J. Wolf

St. Louis Car Co.

THE WOLFWAGON truck is designed to be operated singly, in pairs, or in trains of three or four units, with one driver and all engines running (Fig. 1). Although unconventional in appearance, its basic components are of standard manufacture and, for the most part, interchangeable with those in other trucks in its gvw class.

Powerplant package

The engine can be a diesel or gasoline type. The engine package is a complete unit carrying transmission, radiator, and all accessories on its own subframe (Fig. 2). It is slung amidships or forward in conventional manner. In either case it can be pulled and replaced as a complete package by removing six bolts, unplugging the electrical system, and unfastening quick-connect fasteners and couplings. This can be done in 30 min and the engine given a floor or dynamometer test, as well as checked for oil and water leaks and malfunctions out in the open.

Front axles range upward from 8000 lb capacity, rear axles from 16,000 lb. Dual wheel front axles are set for 18,000 lb and any of the various tandem axles can be used. Air brakes are standard for the doubles; so are tire and wheel sizes. Suspension is conventional, with progressive leaf springs in front and leaf springs with helpers in the rear. The steering gear is a twin cam-and-roller type with ample capacity for high front axle loads.

Flat bed body

The Wolfwagon is without separate cab or fenders. The van-type body runs the full length of the vehicle and has a driver compartment in the left front corner with full windshield for vision. There is a full-length flat floor for loading to the right of the driver, and additional loading area over the driver's head. A pair of units has more loading space than a standard 40-ft trailer.

When the engine is carried forward of the front axle, a half cab and shortened body are used. This configuration permits a front mounting of refrigeration equipment for reefers.

Method of multiple operation

When units are hooked together to form a train, the driver simply controls the lead truck and the trailing units handle themselves. Any unit can be a lead or trailing one. The units are hooked together by an "A" frame and coupling. Controls are carried from unit to unit through quick-disconnect couplings. These controls comprise a throttle hose for trailing engine throttle control, and hill retarder control hose when an Allison Torqmatic transmission is used. When the transmission is conventional a gear selector cable replaces the hill retarder control hose. Brake hose and lighting cable are of the semi-trailer, full-trailer type.

Tracking of the towed vehicle when cornering is determined by the position of the coupling in relation to the rear axle of the towing truck and the

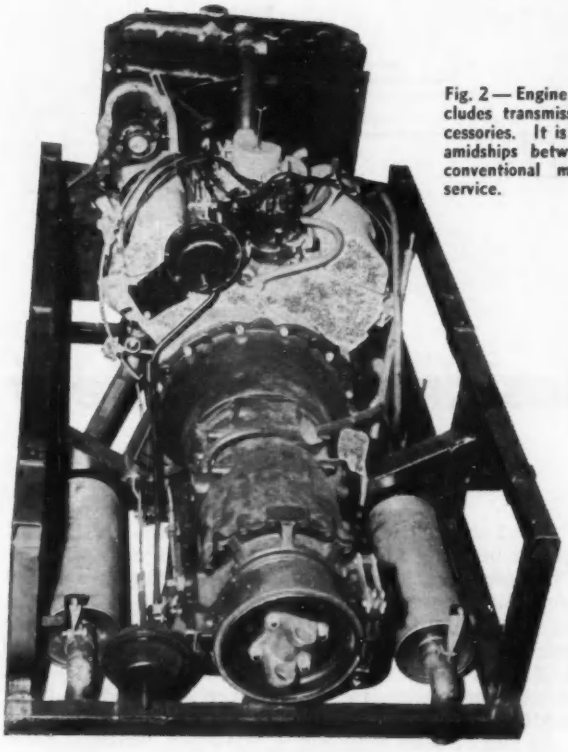

Fig. 2 — Engine package of Wolfwagon includes transmission, radiator, and all accessories. It is carried on subframe slung amidships between axles, or forward in conventional manner, easily pulled for service.

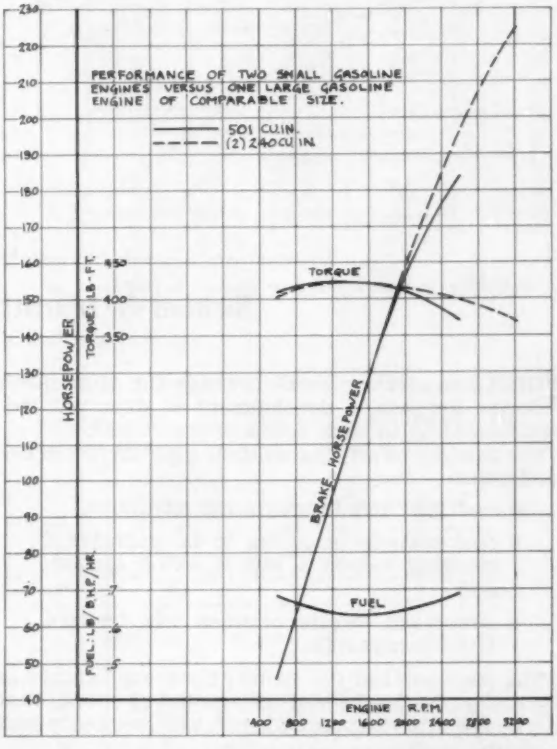

Fig. 3 — Performance of two 240-cu in. engines compared with that of one 501-cu in. engine shows no fuel penalty in multi-engine use. When called upon, the dual engines can deliver more horsepower, and more torque for hills.

front axle of the towed. This distance ratio determines whether or not the tail wags the dog in high-speed, straight ahead running. The tendency of the steering axle is to follow something and in this case it is the coupling.

The throttle is controlled through a sensing valve in the lead unit and a vacuum pump driven by the engine of the towed unit. The sensing valve determines the throttle opening required by the lead unit which is signaled to the towed unit so that its throttle will open in direct proportion to road speed and load. If the towed unit should break away, the throttle shuts automatically.

Vehicle speed and road load determine gear shift points with automatic transmissions and shifting is automatic. With conventional transmissions, the towed unit has a remote shift control so that on manual shift of the lead unit the towed unit follows suit, the clutch being controlled by air-electric signal.

Each unit in a train controls the unit behind it through a sensing valve. If the engine in one unit of a train conks out, the remaining engines carry on. Either engine of a two-unit combination can run the pair. Should the front unit fail, the rear unit engine gets the signal to give more help.

Multiple engine fuel economy

The performance curve in Fig. 3 indicates that two 240-cu in. engines deliver more power throughout the entire working range than a single 501-cu in. engine. When compared at equal horsepower, the pair of engines work at a reduced rpm to put the specific fuel consumption curve slightly to the left, which means less fuel consumption at the same horsepower output. These are, of course, full-power curves. Part-throttle curves might not show up quite as well.

St. Louis Car Co. tests indicate that two engines deliver more power than found in the average truck in the same gvw class, therefore acceleration is faster and there is more torque for hills. The small engine can be short blocked for the cost of a valve job in a larger engine. Driveline components can be smaller, lighter, and less expensive. Tire wear is less because power is spread over more rubber. The single-axle doubles get 62,000 lb gvw on 12 tires, because of the distance between axles, and 84,000 lb on 16 tires. The full tandems are capable of 90,000 lb on 20 tires.

To Order Paper No. 358A . . .
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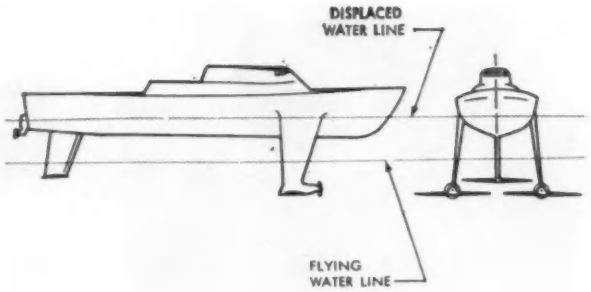


Foils and struts

are major problems when designing for safety

Excerpts from paper by

Richard G. Merritt

Boeing Airplane Co.

FOILS and struts present perhaps the most novel design problem in development of structural design for safety in high-speed hydrofoil ships.

The number of struts and their placement are dependent on:

- customer requirements for retraction,
- performance penalties to be paid for a tracking versus a non-tracking system, and
- downwash effects between the forward and the rear foils.

The placement of the struts affects such things as the hull girder loads; and the amount of energy that can be fed into the predominant, low-frequency hull vibration modes.

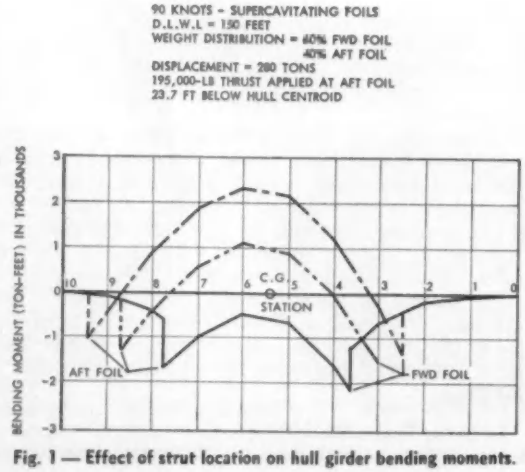


Fig. 1 — Effect of strut location on hull girder bending moments.

Fig. 1 shows the effect of strut location on the hull girder bending moments of a typical hydrofoil ship. The configuration was a supercavitating ship of 280 tons displacement, a water line length of 150 ft, a 40–60% weight distribution between rear and forward foils, respectively . . . and a thrust of 195,000 lb at 23.7 ft below the hull centroid acting on the aft struts and balancing drag forces assigned to foils, struts, and the hull.

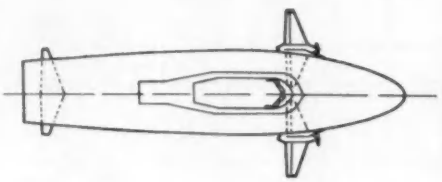
As can be seen from Fig. 1, the strut locations have an important effect on the bending moments. No acceleration factors are included. Similar studies can be made for power forward, power off, various gross weights, and the depth of power application.

Strut length has a vital effect on ship safety. Desire for high-speed cruise in heavy seaways with only minor incremental accelerations would lead to very long struts. Fig. 2 shows the effect of available strut lengths (defined as distance between the hull keel and a minimum foil submergence) on the waves which theoretically can be negotiated in a head sea at 50 knots with an allowable heave acceleration of 0.25g and a "perfect" automatic control system.

At a given wave length, wave heights above the available strut length line would exceed the permissible, but would be negotiable if below the line. A line representing wave-length-to-height ratios of 20:1 and a line representing the Zimmerman wave length are drawn on the figure for comparison. It is seen that 20 ft of available strut length would enable the ship to negotiate most waves up to about 25×500 ft. These waves occur rarely, even in sea state six.

Another aspect of the effect of strut length on ship safety is indicated in Fig. 3, which shows the effect of allowable acceleration on the waves which, theoretically, can be negotiated in a head sea at 50 knots with an available strut length of 15 ft. An allowable acceleration of 0.25g limits the negotiable waves to about 17.5×300 ft, whereas 0.5g gives the ship much greater operational capability in the waves of longer length.

The strut length also dictates the height that the ship must descend or fall in the event of a power failure of foil structural failure. Fig. 4 shows the effect of the speed on the planing velocity parameter during a landing impact.



in fast hydrofoil ships

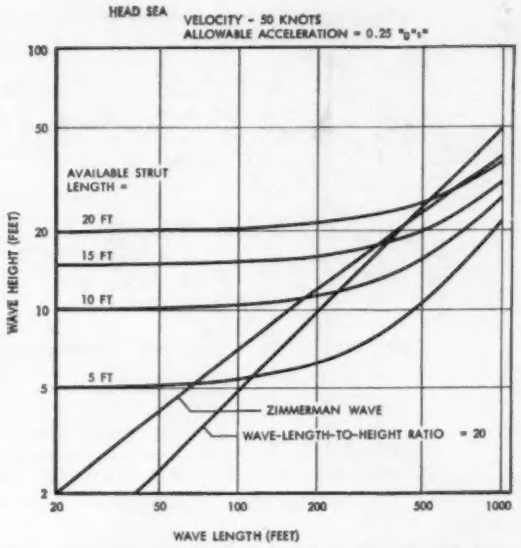


Fig. 2 — Effect of available strut length on wave which theoretically can be negotiated.

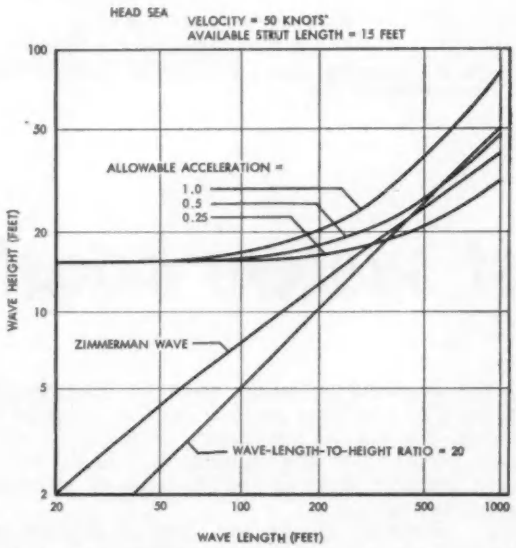


Fig. 3 — Effect of allowable acceleration on wave that can be theoretically negotiated.

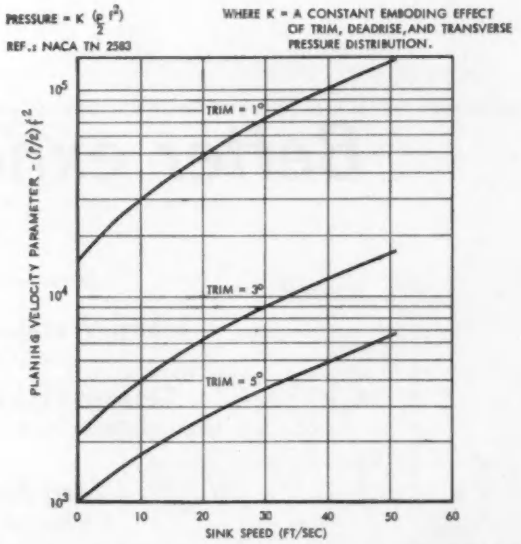


Fig. 4 — Effect of sink speed on planing velocity parameter during landing impact.

The planing velocity parameter is directly proportional to hull panel pressure for a given hull section. A factor of 10 increase in sink speed increases the impact pressure 6-fold for a 1 deg trim. It is obvious that high sink speed landings must be avoided. Airplanes are designed usually for a limit landing sink speed of 10 fps. Loss of power (or throttling the power back) in the foilborne mode of a hydrofoil ship might result in a vertical impact velocity as high as 5 fps.

Negotiating regular waves with an automatic control system and an allowable incremental acceleration of 0.5g results in maximum oscillatory velocities of nearly 3 fps. The most alarming calculation of a vertical sink speed was 45 fps which occurred at the bow of the ship as the result of the loss of the front foil system. This analysis included the heave and pitch degrees-of-freedom and considered the quasi-steady hydrodynamics resulting from the motion. The initial conditions were zero pitch angle and a keel height of 15 ft above the water.

To Order Paper No. 355B . . .
from which material for this article was drawn, see p. 6.

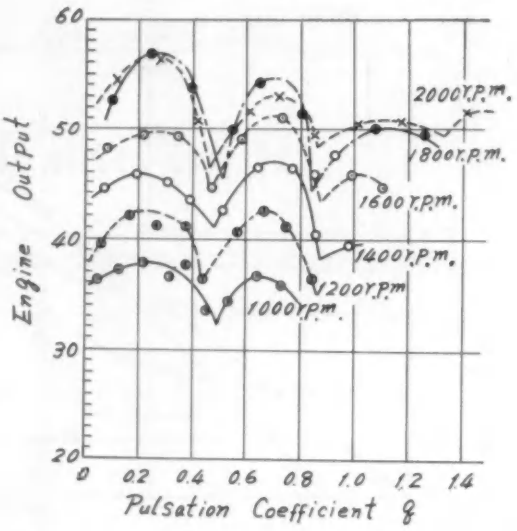


Fig. 1 — Engine output and pulsation coefficient (fuel lever opening 10/12).

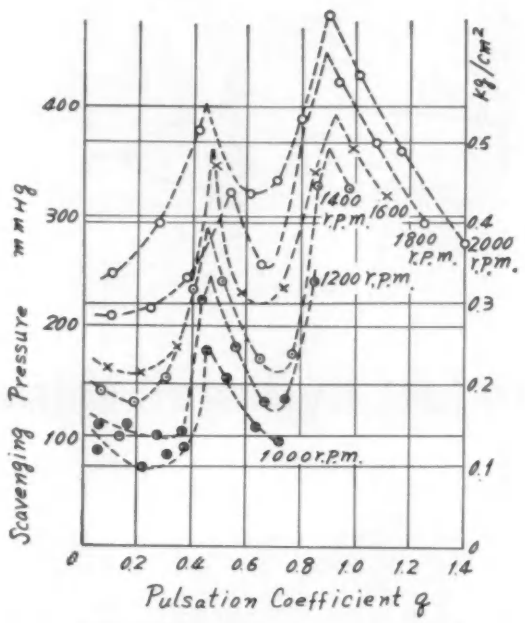


Fig. 2 — Scavenging pressure and pulsation coefficient (fuel lever opening 10/12).

Better exhaust system boosts

Based on paper by

Ichiro Watanabe,
Keio University

Tetsuro Nakada,
Ishikawajima Heavy Industry Corp.
and

Toru Ando,
Keio University

Improved scavenging and charging, which combine to give better performance, can be attained for 2-cycle engines through proper tuning of the exhaust system. Tests performed on a UD3 2-cycle diesel engine, recently, showed a 15% difference in output between the most favorable and unfavorable pulsation conditions. It was also found that a 4–10% improvement in horsepower can be realized with diffusers installed in the exhaust lines.

Pulsation is an important influence in 2-cycle engines because the cylinder flow phenomenon depends primarily on the difference between scavenging and exhaust pressures. The optimum condition occurs when the pressure wave, produced just downstream of the exhaust valve during the exhaust blowdown period, is superposed on the positive part of the residual pulsation wave of the preceding cycle. The resulting positive exhaust wave is very strong. During the scavenging period the negative wave, produced by the counteraction of the positive wave, becomes large enough to improve scavenging and charging.

An important parameter used in dealing with these effects is the pulsation coefficient q. It is defined as the ratio of the fundamental frequency of the gas column within a pipe closed at one end, to engine speed. For certain values of q, 0.24, 0.70, and 1.16, engine output reaches maximum values. This is shown in Fig. 1, plotted for a particular fuel lever setting of the test engine. The same tendencies are exhibited at other settings.

The output variations decrease as q becomes larger or the pipe length greater. Damping of the pressure waves by frictional resistances and the influence of residual waves in the pipe might account for this.

The effect of q on scavenging pressure is shown in Fig. 2. Note that lower scavenging pressure corresponds to points where higher output is achieved.

The length of exhaust pipe required to give favorable conditions in the engine can be computed from the equation:

$$q = \frac{nL}{15c}$$

where n is the engine speed (rpm), L is the length

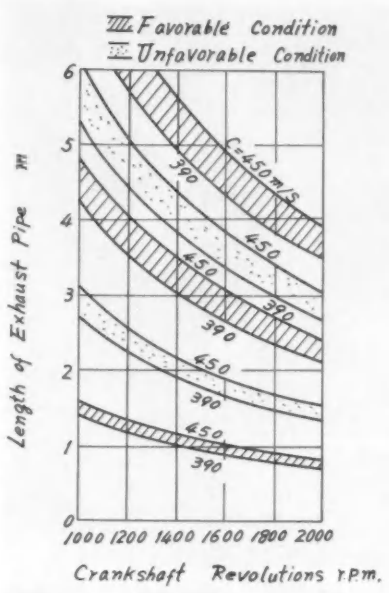


Fig. 3 — Length of exhaust pipe needed to produce favorable exhaust conditions.

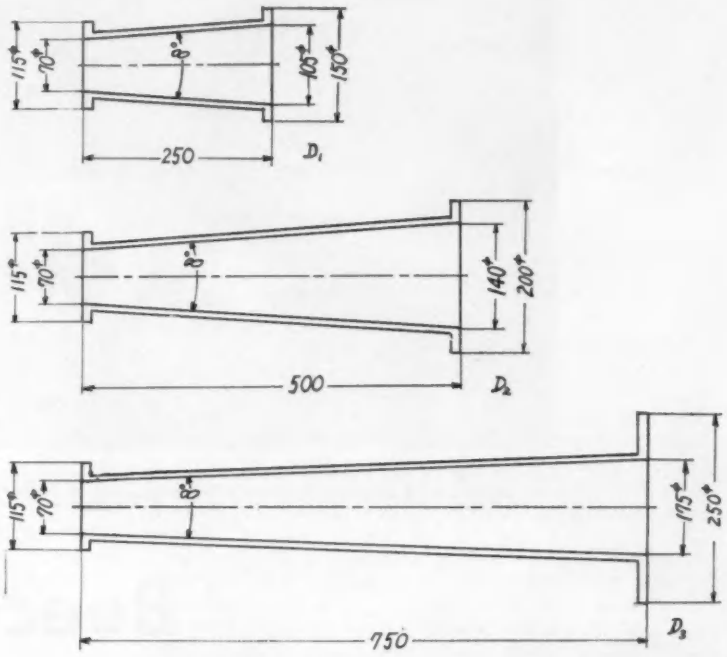


Fig. 4 — Diffusers of different area ratios used in the engine exhaust system.

engine output

of the exhaust pipe, and c is the sonic velocity in the pipe. The pipe lengths most conducive to good tuning are the values of L found by substituting the optimum q values into the equation. These are plotted in Fig. 3 for different engine speeds.

In the case of a constant speed engine no special attention is necessary. For variable speed engines, however, the shortest pipe length that permits operation in a favorable region is preferable. With a short pipe, pulsation effects are seen to be less sensitive to speed variation.

When diffusers such as those shown in Fig. 4 are used, the output increases further, as shown in Fig. 5. A new parameter Q is used in this plot and is defined by:

$$Q = \frac{90}{\theta_e} \cdot q$$

where θ_e is the exhaust lead angle (deg).

The diffuser action is more effective at higher speeds, probably because of larger weight flows of exhaust gases. It was noted in the tests that the diffuser effect increased above 1400 rpm as the engine speed and diffuser area ratio increased.

Also tested were the effects of nozzles, bends and elbows on pulsation. They were found not to have significant effects.

To Order Paper No. 367B . . .
from which material for this article was drawn, see p. 6.

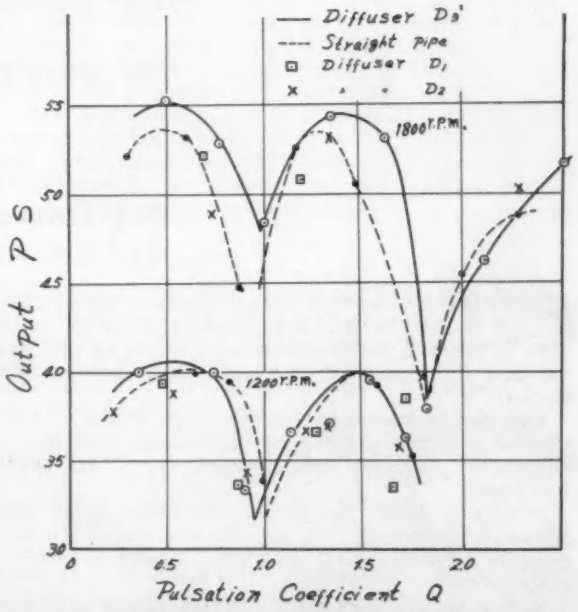


Fig. 5 — Output and pulsation coefficient, with and without a diffuser. The only diffuser curve is that for D_3, although points for the other two diffusers are shown.

Fig. 1 — The PD 146, a high-performance twin turboprop, undergoing flight tests over France. Designed as a fly-it-yourself airplane, it is being developed by Beech in association with SFERMA, Turbomeca, and Ratier-Figeac, all of France.

Beech developing twin turboprop

High performance, simple operation sought for personal-type airplane now under test

Based on paper by

M. J. Gordon

Beech Aircraft Corp.

EXPERIMENTS to date indicate that an interesting and useful, small, twin-engined airplane, with very attractive performance capabilities can be developed for a price that should have considerable appeal.

Complete answers to five questions vital to a successful program depend on continued experiments scheduled for early 1962 completion. These questions are:

1. Can a small, personal-type, twin-engine airplane be developed with turbine engines which will provide performance a generation ahead of present airplanes?

2. Can satisfactory flight characteristics be developed so that all kinds of pilots, including businessmen owners, can fly the airplane?

3. Can the problem of noise be solved satisfactorily?

4. Can an engine installation be developed to have good overhaul life, reasonable fuel consumption, and easy operation?

5. Can an airplane be developed that will not suffer too heavily from penalties imposed by any present or anticipated FAA regulations?

We don't know all the answers yet, but we know a lot more than when we started to work with the Beechcraft Travel Air Model B95A as a test bed. This airplane is powered by two 180-hp Lycoming 0-360 piston engines and has an approved gross weight of 4200 lb. From this was developed the Beechcraft Baron Model 55, powered by two 260-hp Continental 0-470 piston engines, and having an approved gross weight of 4800 lb. At a gross weight of 5500 lb, the projected turboprop, the PD 146, can be loaded with full fuel, five people, radio and optional equipment, and still provide for 78 lb of luggage.

This airplane is being jointly developed by Beech, SFERMA, Turbomeca, and Ratier-Figeac (Fig. 1).

Airframe structure

The basic test bed airframe was good for about an 8*g* load factor. Therefore, little change was required to provide for the higher gross weight. During flight test it was found desirable to add stiffness to flaps and ailerons. A design dive speed V_d of 315 mph was selected and ground tests show the critical flutter speed to be well above the design dive speed.

Turbine powerplant

The test bed engine was Turbomeca's Astazou I, a fixed shaft turboprop. It has one-stage axial compression and a second stage centrifugal compressor. The overall pressure ratio is 5.7/1. The engine is equipped with a 3-stage axial turbine and it is rated at 43,000 rpm for take-off and maximum continuous, has a 440-shaft hp rating for take-off and 394 hp for maximum continuous. A reduction gear produces 2400 rpm at the propeller.

The current version of the Astazou engine, the IIA, has now been installed in the test airplane. Ratings have been increased up to 562 shaft hp for take-off and 493 for maximum continuous. Ratings are to be maintained at approximately 400 shaft hp maximum continuous and normal, and in spite of this derating, performance shows specific fuel consumption to better than with the Astazou I.

Flight performance

Flight tests show maximum cruising speed to occur at approximately 15,000 ft and has been measured at 278 mph (Fig. 2). Maximum sea level cruising speed is limited by V_C (maximum structural cruising speed) which has been selected to be 255 mph. Use of turbines has made possible a cruising speed 53 mph faster than that of the Beech Baron.

A rate of climb of 3150 fpm at sea level has been measured. Single engine climb at sea level is equally impressive 940 fpm. Ceilings are comparable, having been measured as 31,500 ft absolute for two engines and 21,000 ft for single engine. The theoretical range at 10,000 ft with no reserve, based on 200 gal kerosene, is 830 statute miles at the maximum 270-mph cruising speed. At 230 mph the range figures out to be about 900 miles, but increasing considerably at higher altitudes. This range is expected to increase with the Astazou IIA.

The flight test results were somewhat disappointing because power required at a given speed appeared to be more than for the piston-engine Beech Baron. No explanation for this discrepancy has been found, but better results are anticipated from the new engines. Some redesign to reduce drag and increase inlet efficiency is under study.

Simplicity of control

The propeller-engine control system is a radical departure. The propeller pitch remains constant at a value selected by the pilot, and engine power is varied through the use of a mechanical governor. The governor controls fuel flow which adjusts power to compensate for changes in airspeed and changes in the selected propeller pitch setting. Essentially, the pilot controls power by means of a pitch control lever calibrated to indicate actual pitch setting of the propeller. A second lever is used to set the various speed ranges for such operations as starting, taxiing, take-off, and cruise. To prevent overpowering the engine, an electrical pressure ratio limiting system automatically reduces propeller pitch to maintain the maximum permissible pressure ratio. An indicator light tells the pilot when this condition occurs.

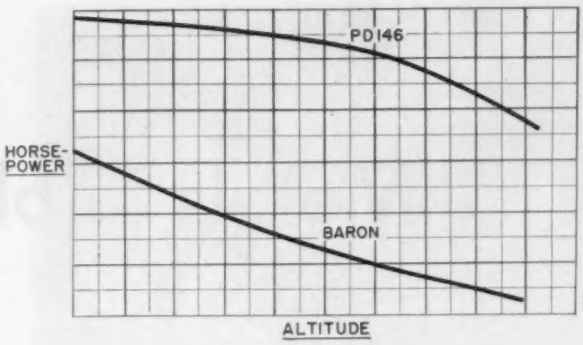


Fig. 2 — Comparison of power available at altitude for the PD 146 twin turboprop and the Beech Baron with piston engines.

A button is pressed for take-off which automatically provides 440 shaft hp throughout the take-off and climb. At test weights of 5000 lb, climbs to 10,000 ft have been accomplished easily in 3½ min, after a short run. At letdown from 10,000 ft the control system really demonstrates what it has. The engine control tends to maintain rpm by reducing fuel as the airspeed is increased. Pushing down the nose of the PD 146 would tend to overspeed the engine, but this is corrected by reduction in fuel flow so that it is possible to let down at any desired indicated airspeed, including cruise airspeed, without concern for exceeding design speed. Actually, the propeller tends to act as a dive brake and the rate of descent can easily be adjusted and on touchdown an extremely short landing run can be achieved by putting the propeller into ground fine pitch position.

The engine-propeller control system appears to answer the requirement for simplicity of pilot operation and in addition will reduce the cost of the engine-propeller combination by about 30% as compared with a conventional system.

Unsolved problems

The noise level has been disappointing. Studies are underway to determine the cause and find ways to reduce it. The major source is high frequency and seems to be caused by the compressor section of the turbine. There are several points of attack and efforts do show promise.

Higher than anticipated fuel consumption is a problem that the newer model engines should abate. Finally, there is flight test work to be done on stability control and handling characteristics, and more data needed on trim power, stall characteristics, and elevator power at the extremes of the c.g. envelope. Even so, the answer to all questions at this time appears to be a qualified "yes."

To Order Paper No. 365C . . .
from which material for this article was drawn, see p. 6.

Metals and plastics compared

. . . by two engineer-editors –

for today's "service oriented" designer,

who is concerned chiefly with performance specifications.

Based on paper by

M. W. Riley and Donald Peckner

Associate Editors
Materials Design Engineering

MORE AND MORE specifications for both metals and plastics are being written as performance specifications. The designer's major concern today is to find and apply a material or materials with the right combination of engineering properties to meet a particular set of design and service conditions. This "service oriented" attitude looks primarily at the *properties* of particular metals and particular plastics; is less concerned with "*specifications*" in the usual sense.

Looking at metals in general, the service-oriented engineer sees them as having such qualities as:

electrical conductivity; thermal conductivity; high strength; dimensional stability; heat resistance; weatherability, and hardness.

Looking at plastics in general, he sees in them such qualities as:

ease of forming and fabrication; electrical insulating characteristics; thermal insulation; corrosion resistance; light weight; colorability; and, in some cases, transparency.

Then, looking more closely, he sees the variety of ways in which all of these materials can be viewed as complementary from a design standpoint.

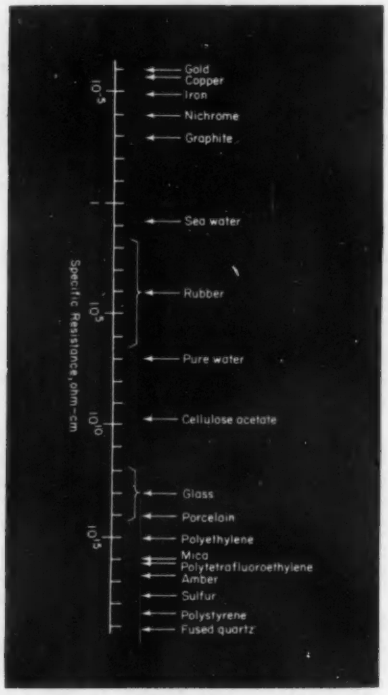


Fig. 1 — Resistivity spectrum of representative metals and plastics.

Physical Properties Compared

ELECTRICAL RESISTANCE: Metals are conductors of electricity. Silver and copper, for example, are standard *conductors*, which are applied where plastics generally cannot be used.

Plastics on the other hand are electrical *insulators* — and are used as such in many applications such as hand tools, distributor parts, and vacuum tube bases.

Fig. 1 shows the resistivity pattern for metals and plastics. Values range from 10^{-6} ohm-cm for gold to 10^{19} ohm-cm for a high-performance polystyrene. (Plastics can conduct electricity to a degree, if a conductor is mixed with resin before it is formed. For example, a carbon-filled DAP compound is being used by New England Instrument Co. to replace resistance wire in a precision potentiometer.)

A more subtle design consideration is illustrated in

an appliance housing. Here the conductive metal would be desirable because it would ground static charges; reduce chances for collection of dust on the housing. . . . But, if the housing is to contain electrical equipment, a non-conductor would provide an additional safety factor.

Chrysler's Valiant instrument panel, for instance, is molded in acetal plastic, but requires a grounding strap to ground the enclosed instruments — an additional cost, which would argue for a conductive housing. Buick, on the other hand, uses an ABS plastic instrument panel backing with a molded-in printed circuit, thus making full use of the insulating characteristic of the plastic.

THERMAL CONDUCTIVITY: Plastics are notable thermal insulators; metals notable heat conductors. In design, the value of conductivity or lack of conductivity depends on the needs of the particular product.

Thermal conductivity value for most plastics is approximately 0.1 Btu/ft/hr/ft²/F. This compares with values of 222 for copper, 28 for cast iron, 10 for Type 302 stainless steel, and 97 for tungsten.

Heat capacity of plastics — on a weight basis — is 3 to 4 times that of metals. This permits plastics to absorb high heat input and to localize heat effect for a short time, thus contributing to success in such uses as nose cones for missiles. On a mass basis, specific heat of plastics is about 0.3–0.4 Btu/lb/F. Iron and copper have specific heats of about 0.1 at ordinary temperatures.

On a volume basis, specific heat of plastics is much lower than that of metals because of the lower density of plastics.

WEIGHT: Light weight can be an advantage or a disadvantage in a particular design. It may be a decisive advantage in one design; a decisive disadvantage in another.

Light weight is a major benefit usually sought from plastics. But greater weight is often needed, as, for instance, to provide proper governing action; to give a "feeling" of stability; and for many other reasons.

EXPANSION: Differences in thermal expansion characteristics between metals and plastics are very great. In plastics, the coefficient of expansion may range from about 4×10^{-5} per deg F for phenolics to 6×10^{-5} per deg F for cellulose acetate.

Coefficients of metals are many times lower than of plastics. Metals' coefficients may run from about 0.8×10^{-5} per deg F for mild steel to about 1×10^{-5} per deg F for ordinary brass.

These differences in coefficients of expansion obviously lead to special problems when combination of metals and plastics is attempted in a design.

COLORABILITY AND APPEARANCE: Plastics cannot be matched for colorability. The range and depth of colors offered by plastics can only be approached by special coating or finishing processes on metals.

Sometimes, however, this inherent plastics advantage can't be effectively used. The plastic Valiant instrument housing, for example, is painted after being molded. Reason: it was found to be more economical to paint all the housings than to try to schedule the proper proportion of the proper molded-in colors to match planned color proportions in the painted dash.

It's hard, on the other hand, to duplicate in plastics the durable, glistening chromium plates obtainable on zinc die cast exterior automobile parts. Metallized coatings on plastics do not provide the durability of chromium electroplates.

OPTICAL CLARITY: Light transmission — a useful

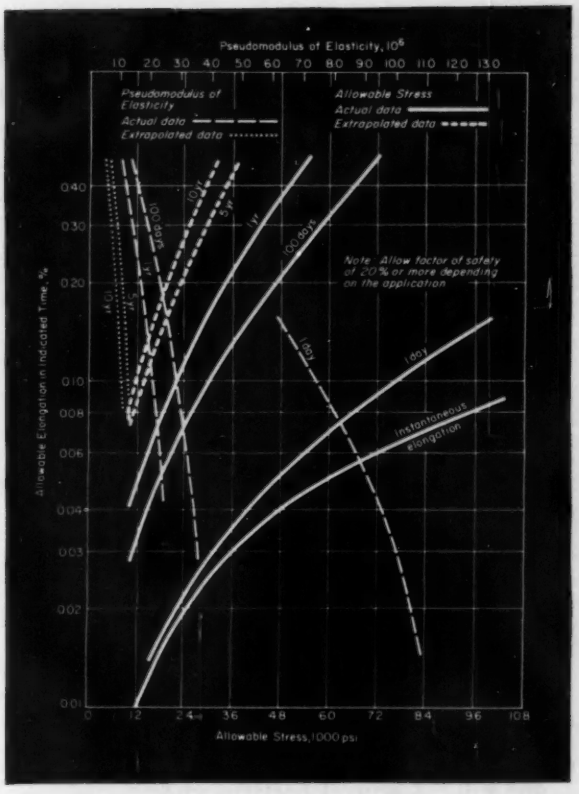


Fig. 2 — Relationship of mechanical and physical properties of zinc to time and exposure values.

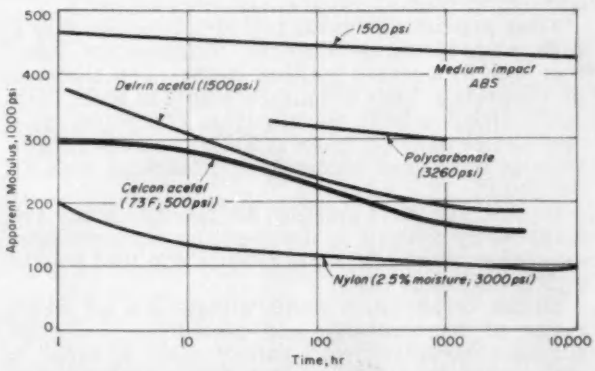


Fig. 3 — Relationship of mechanical and physical properties of several plastics to time and exposure values.

Metals and plastics compared

. . . continued

property unique to some plastics — can't be duplicated in metals. Acrylics, certain cellulosics, and general-purpose polystyrene are among the plastics which provide glass-clear transparency. This makes them useful for windows, camera lenses, and many optical devices.

This ability to transmit light is useful also in photoelastic stress analysis and many decorative applications. Most decorative escutcheons for automobiles and appliances, for instance, are made of transparent plastics, the second surface of which has been metallized. The result is a depth of color and visual effect difficult to duplicate.

CHEMICAL RESISTANCE: Both plastics and metals are widely used to provide chemical resistance. Individual plastics, however, have a breadth of resistance to corrosive agents equal to and usually greater than that of most commercial metals and alloys.

Fluorocarbon plastics, such as Teflon, for example, are inert to practically all chemicals — except for some molten metals. Vinyls are extremely inert to most alkalies, oxidizing agents, and inorganic acids. Certain vinyls withstand attack by grease and oils — and will not support bacterial growth.

Polyethylene and polypropylene are highly resistant to most acids and alkalies — except oxidizing acids. Styrenes withstand salts, acids, and alkalies. Certain special styrenes resist cleaning agents and solvents, kerosene, gasoline, and essential oils.

Thus, plastics as a group provide protection over a wide range of corrosive agents. Temperature, however, can be a severe limiting factor. Few thermoplastics retain their chemical stability at more than 212 F. High density polyethylenes and polypropylene may be used up to about 250 F; and the fluorocarbons have good corrosion resistance as high as 300–550 F.

Plastics also have pressure limitations. Many are attacked by solvents or decomposing environments. One other drawback: some rodents find that plastic pipe is unusually tasty.

Metals, on the other hand, withstand a far wider range of temperatures and pressures . . . even though individual metals cannot resist as broad a group of reagents. In general, a metal satisfactory in a reducing corrosive environment is ineffective under oxidizing conditions and attention must be given to potential corrosion between dissimilar metals.

WEATHERABILITY: Weatherability of metals depends strictly on effects of moisture and chemicals in the environment. Metals are unaffected by ultraviolet light.

Most plastics, however, are susceptible in varying degrees to attack by ultraviolet radiation, except for fluorocarbons, acrylics, and butyrates which remain virtually unaffected. Indoor lighting can also be harmful to plastics. Incandescent light emits a relatively small amount of ultraviolet energy and thus is not particularly harmful. Fluorescent light, however, emits a higher percentage of ultraviolet and can affect plastics adversely.

Pigmenting or filling plastics with materials such as carbon black or other dark pigments substantially improves ultraviolet stability.

Moisture absorption is often held up by metals men as the shining example of why plastics are not logical engineering materials. This is a problem — but an overrated one. Plastics do absorb moisture and metals do not. But consider that the moisture absorbing dimensional changes — are absorbed. Some plastics, principally the fluorocarbon thermosets do not absorb moisture. This is an engineering factor that must be considered.

MECHANICAL PROPERTIES: One fundamental difference should be noted at the outset: properties of plastics are much more time-sensitive than those of metals. Consequently, strength values are highly dependent on speed of loading. Strengths of plastics are also much more dependent on environmental factors such as humidity, and temperature, than are those of metals.

With the metallurgical history available, properties of metals can be stated with a high degree of accuracy. But the metallurgist is taken back by the apparent volume of mechanical property data generated by plastics engineers — along with the qualifications, gaps, and lack of cohesiveness of the data. Besides, accurate structural design in plastics is only starting to emerge. The theory of reinforced plastics structural design is well developed, but complexity of the materials limits the practical application of theory. In most uses, safety factors must be so excessive that by no stretch of the imagination can the design be called efficient from the standpoint of optimum use of the material.

In thermoplastics, there is even less structural design. The nature of the parts for which thermoplastics are applicable is generally such that detailed stress analysis is impossible or impractical. Where such analyses can be made, understanding of the effects of time, temperature, environment, and stress on the behavior of the materials leaves much to be desired. Consequently, strength data subsequently quoted for plastics in this article should be considered qualitatively.

TENSILE STRENGTH: Metals and plastics form a strength continuum ranging from approximately 2000 psi for low density polyethylene up to 500,000 psi for cold drawn stainless steel wire. This wide strength range offers the engineer a very broad base for design, assuming that all other design requirements are met by the material chosen.

Nonreinforced plastics have only moderate mechanical properties ranging up to 16,000 psi tensile strength. But reinforced plastics are capable of reaching much higher strength levels.

Glass-reinforced plastics generally have tensile strengths ranging from a low of 8000–25,000 psi for a mat-reinforced polyester, to 40,000–85,000 psi for a cloth reinforced epoxy, to 180,000–230,000 psi for a unidirectionally reinforced filament-wound epoxy structure. (Strength of reinforced plastics is orthotropic and is primarily dictated by the direction

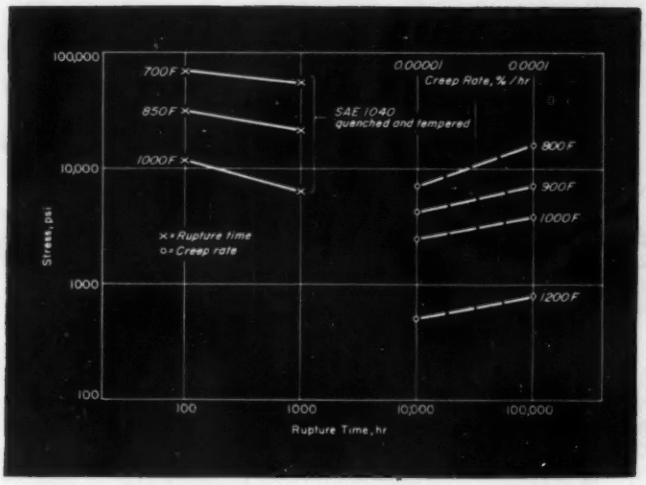


Fig. 4 — Carbon steel creep rate is less than that shown by zinc or plastics.

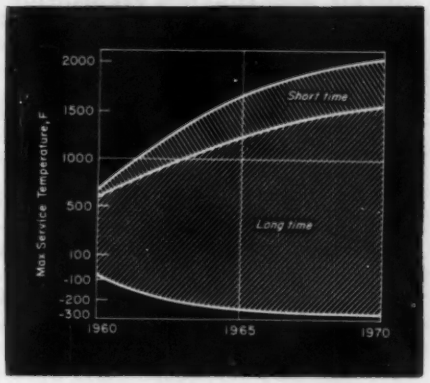


Fig. 5 — TEN-YEAR prediction of service temperatures for plastics.

of the fiber reinforcement in the material.)

In tensile strength, then, cloth-reinforced plastics are about as strong, on a volume basis, as aluminum alloys. On a volume basis, weaker reinforced plastics are about ⅓ to ½ as strong in tension as structural steel. Intermediate strength reinforced plastics are comparable to structural steel.

On a unit weight basis, the substantially lower density of plastics alters the picture. For example, using a nominal density of 0.065 lb/cu in. (1.8 g/cu cm) for glass-reinforced laminates, tensile strength-to-weight ratios for a nominal mat-reinforced polyester of 16,000 psi would be 246,000 in.

Strength-weight ratio for a nominal cloth-reinforced epoxy of 65,000 psi would be 1,000,000 in.

Strength-weight ratio for a nominal filament wound epoxy of 200,000 psi would be about 3,000,000 in.

CREEP AND COLD FLOW: Metals such as lead and zinc "creep" at room temperature. So, strength and elongation must be carefully calculated for the period of service and service stress. The majority of metals, however, can be applied up to 500–600 F without regard to potential creep problems. Creep occurs in metals at these temperatures but at an infinitesimally low rate that does not noticeably affect dimensions.

Plastics, on the other hand, require careful consideration of creep, or cold flow, at all temperatures of application. The problem is acute even at room temperature and becomes more serious as temperature increases.

There are two aspects of the problem: creep, or deformation under constant load and relaxation; and decay or force at constant strain. Use of relaxation to stabilize a structure works like this: the part is deformed under stress; relaxation gradually occurs and when stress has decayed to a low level, removing the deforming force results in a dimensionally stable structure.

Fortunately, creep modulus is equal to relaxation modulus so that the use of only one time dependent modulus — the apparent modulus — is necessary. (Metals such as lead and zinc are characterized by a pseudo modulus.) Apparent modulus E is defined as:

$$E = \text{stress/strain at time } t$$

and $t = F_o/A_o/\Delta L_t/L_o$

where F_o = consant force, lb
A_o = original cross-section area, in.^{2}
L_o = original length, in.
ΔL_t = increase in length during t, in.

Figs. 2 and 3 show how mechanical and physical properties of zinc and several plastics vary with time and exposure. Fig. 4 on the other hand, shows that carbon steel creep rate, although affected by time at temperature, is not a design problem of the magnitude encountered with plastics . . . or zinc or lead.

RIGIDITY: Plastics lack rigidity, relative to metals, and this characteristic restricts their use in a large number of structural applications. The modulus of plastics is generally low, ranging from $3-8\times10^5$ psi for nonreinforced up to 30×10^5 psi for reinforced plastics. Comparative values for metals, in general, range from 100 to 450×10^5 psi. Since plastics bend under load much more easily, and to a greater extent than metals, they are eliminated from designs where flexure under load is critical or must be minimized.

Low modulus on the other hand, is an advantage in many applications. Interference fits can easily be made and plastics can be molded in complex designs which can be snapped out of the molds — an impossible feat for metals.

STRENGTH–TO–WEIGHT RATIO: The great advantage of plastics, in general, is their high strength-to-weight ratio.

Average density of plastics ranges from 1–2 gr/cu cm, with the glass-filled plastics on the high side. An epoxy-woven fabric reinforced plastic, with a tensile strength of 85,000 psi and a specific gravity of 1.85, has a strength-to-weight ratio of 1,270,000 in. This value can be compared with 710,000 in. for heat treated SAE 4140 (tensile strength, 200,000 psi) or 1,370,000 in. for the heat

Metals and plastics compared

. . . continued

treated beta titanium alloy, 13 V-11 Cr-3 Al (tensile strength, 240,000 psi).

If their high strength-to-weight ratios could be maintained at elevated temperatures, new vistas of usefulness for plastics would be opened. However, the high room-temperature values are a factor in the mechanical acceptability of plastics.

MAXIMUM OPERATING TEMPERATURE: Heat resistance of plastics is not easy to state in meaningful or in definitive terms. Thermoplastics gradually soften as they approach their softening point, losing strength and dimensional stability. Thermosetting plastics lose strength and ultimately char to destruction. How can we state a meaningful temperature limit? A common measure is the ASTM heat distortion temperature; another a so-called "maximum recommended service temperature."

The heat distortion temperature is virtually meaningless beyond its value as a general indication of comparative heat resistance of a specific specimen, loaded in a specific way, and under a specific stress. The maximum recommended service temperature tells us only that workers, by experience, have found this to be the highest temperature at which the material can be safely used under ordinary conditions. What these ordinary conditions are, in terms of type and degree of stress, and type of exposure, is somewhat obscure.

In general, then, thermoplastics may be useful at maximum continuous temperatures ranging from about 140–150 F for general purpose polystyrenes and low density polyethylenes, to 185–250 F for the acetals and nylons, to about 500 F for fluorocarbons.

In thermosetting plastics, maximum continuous use temperatures are in the 500–600 F range for specially developed materials, such as phenyl silanes, certain modified phenolics, and some newer epoxy materials.

Mention should also be made of the much publicized service provided by reinforced plastics at the 5000–25,000 F temperature encountered in space flight and reentry. These materials are being used up, however, rather than used. Time required to destroy or pyrolize the material is sufficient to permit the material to perform the necessary function of thermal protection.

Fig. 5 gives some idea of anticipated temperature required of all plastics by 1970. The maximum temperature, close to 2000 F, is almost as high as the 2200 F anticipated requirement for some superalloys.

In the long run, the designer is the man who benefits from the competition between metals and plastics. At his drawning board, he is free to combine metals *with* plastics, according to how each best suits the particular design upon which he is engaged at a particular moment.

To Order Paper No. 381B . . .
from which material for this article was drawn, see p. 6.

Immediate answers; complete and accurate

What PRODUCT of production

Based on presentation by

G. R. Fitzgerald
AC Spark Plug Division, GMC

PRODUCT ENGINEERS must take the initiative to establish the close communication with production engineers that everybody agrees is necessary in modern industry. When a product engineer's responsibility for function precludes his acceptance of a production engineer's recommendation, he should explain WHY he can't say "Yes." He shouldn't be content merely to state his decision.

When reasons accompany decisions, the production engineer isn't nearly so likely to bemoan the stubbornness and lack of interest in manufacturing problems by the product engineer.

In taking the initiative for good communications, the product engineer should be clear about what he requires; what he expects or hopes for from the production engineer. This he can do by being specific. Some of the important things the product engineer wants from the production engineer are:

- Immediate answers.
- Complete understanding.
- Thorough consideration.
- Accurate and factual information.

IMMEDIATE ANSWERS: The design engineer usually is trying to meet some kind of deadline. Usually he can't put an item aside and turn to something else for a week or two while a detailed cost study is being made.

> **The production engineer must be willing to commit himself even though a long study may be necessary and may even force a change of plans later on.**

The delays involved have been major stumbling blocks to better communication between product and production engineers. A request to design an item completely in several alternative forms for later cost evaluation often looks to the design engineer like a delaying action. Somebody, he is likely to think, is unwilling to accept decision-making responsibility.

understanding; thorough consideration; factual information are . . .

engineers expect engineers

G. R. FITZGERALD has been in the middle of "communications" between automotive designers, production engineers, and manufacturing men for a good many years. He speaks with the voice of experience.

In this article, his ideas are expressed frankly. No punches are pulled. He lays on the product engineer responsibility for initiative in establishing better communications with production engineering. But he is specific about ways in which production engineers can keep the communication channels open.

Fitzgerald is currently director of AC Spark Plug engineering, having joined this GM division in 1935. From 1953 to 1957, however, he was director of the GM process development section in Detroit. From 1951 to 1953 he had been assistant chief process engineer at AC.

COMPLETE UNDERSTANDING: When a design engineer has complete understanding of the reasons behind processing information which he receives, he tends to catalog it for possible use in later similar situations. He likes to know the criteria by which a processing decision is made, so that he may save time by making it himself on the next occasion.

It is not enough for him to know, for example, that a particular component should be made by cold extrusion rather than by machining. This is particularly true where an obvious design choice must be ruled out because plant equipment lacks the flexibility or capacity to handle it.

Limits of production equipment (as to size, flexibility, or any other criteria) should be well documented for the product engineer's reference and guidance.

THOROUGH CONSIDERATION: If he establishes maximum communication with production engineering when he starts a design, the product engineer has a right to expect a minimum of production-inspired engineering change requests when the job is ready for production. He has a right to expect a thorough consideration of all parts of the design — and an adequate representation of all different viewpoints early in the design process.

So, production engineers must have sufficient and adequate communication with manufacturing supervision to represent the latter's views as well as their own.

For example: In one of AC's new instrument panels, the diecast decorative housing was developed as a cooperative effort between the product and the production engineer. When the drawings were completed and first reviewed by manufacturing supervision, that group recognized many obvious advantages from a manufacturing standpoint of a 2-piece design. Further study proved their approach to be the most practical one. And after some delay the casting was redesigned in two separate pieces. *This redesign could have been avoided if production engineering responsibility had been properly met.*

ACCURATE AND FACTUAL INFORMATION: A minimum of personal opinions and a maximum of factual information in every contact will go far to reduce one area of great conflict between product and production engineers . . . the area: dimensional tolerances.

Product engineers are regularly accused of specifying ± 0.002 on their drawings when they know that ± 0.004 may be adequate . . . in order to be sure to get the ± 0.004.

Production engineers, on the other hand, are accused of being insensitive to "tolerance stackup" and to functional problems.

Each group needs a more complete understanding of the other's problems . . . which can best be brought about by presentation of factual information as contrasted to personal opinions.

If, for example, product engineers got accurate data about the added cost of close tolerances, they would be more receptive to reviewing the tolerances, than if they are told only "not practical" or "impossible." . . . And if the production engineer were led through the design analysis that had developed the close tolerances, he might be able to suggest other less costly solutions to the problem. A group of dimensions may be adjusted to closer limits without adding cost to avoid a single limit that is unreasonably expensive or difficult to hold consistently.

Complete communication between product and production engineers could permit release of a design that would be free from later changes . . . those changes which come as others get a chance to second-guess the product engineer's efforts.

There are probably as many schemes to achieve this engineering utopia as there are engineering departments. They all have the problem of improving communications; all are working on it; but the perfect solution still lies in the future.

The "glue line"

is finding its way into motor vehicle production

Based on paper by

Irvin E. Poston, Kenneth D. Downing, and Kenneth J. Mack

Manufacturing Development Plastics Laboratory, General Motors Corp.

THE "GLUE LINE" is finding its place in automotive production. That thin film of adhesive between two parts which are bonded together is forging ahead slowly but surely in the automobile as well as the aerospace industry. The future of adhesive bonding seems limited now only by the ingenuities of the adhesive chemist, the process engineer, and the product designer.

Often referred to as chemical welding, adhesive bonding has distinct possibilities in addition to those displayed by most conventional types of mechanical fastening. Its advantages over riveting, screwing, and welding may include:

- Better appearance than either a welded or riveted joint. A 5 mils glue line can be used in visible areas almost invisibly.
- Elimination of weld dimples; no buffing down the part after joining.
- Elimination of warping of part — because of the lower heat used for adhesive bonding, as compared to the high and uneven heat of welding.
- Provision of a seal that is impervious to salt, gasoline, oil, and other materials.
- Provision of thermal, electrical, and sound insulation. (Adhesives' sound deadening properties are already used in automobile rear deck lids and hoods, where adhesives are used to supplement welds.)
- Cost of capital equipment may be lowered, *IF* the ideal adhesive can be developed.
- Distribution of load over a much larger area, because *ALL* the bond area can be utilized by the adhesive.
- Horizon of design possibilities is expanding rapidly.

Despite these potential advantages, adhesives have several obstacles to overcome before they can be generally used to hold cars and trucks together. (The experimental trucks already made with structural members bonded together merely prove a principle; they don't provide an adhesive or a process adaptable to production).

Among these obstacles:

1. More work is needed in development of adhesives applicable to mass production methods.
2. More work is needed to adapt mass production methods to adhesives.
3. Product designers need to become aware of the potentials of adhesives and develop confidence in them.
4. Parts must be designed for adhesive bonding — if adhesive bonding is to be successful.
5. Adhesive bonding is a relatively recent innovation.

Gradually, however, these obstacles are being overcome, as is evidenced by the many applications where adhesives already are being used.

Close to possible automotive uses, for example, is the bonding of metal ends to the paper filter material in gasoline and oil filters. In this case, only adhesives can do the job.

Then there are the adhesives used for bonding rubber weather seals to doors of cars and trucks. If the rubber is properly cleaned, the rubber strip itself will fail before the adhesive bond is broken. (As in the filter bonding application, adhesive use is dictated by the fact that rubber and paper are very hard to fasten by any other method. Only adhesives provide both a bond and a seal.)

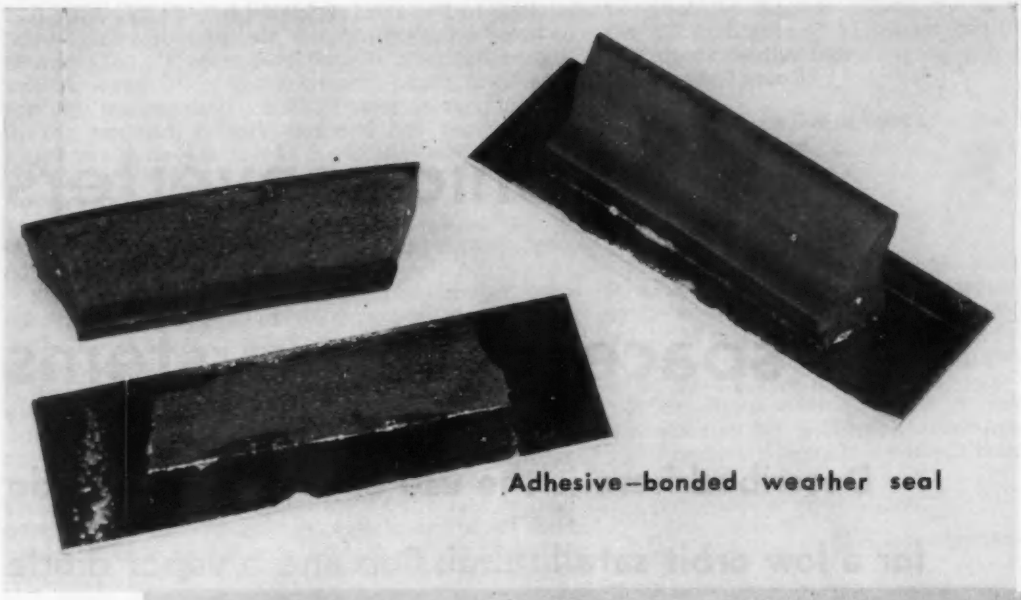
The bonded brake shoe is another application which has proved that adhesives perform satisfactorily under severe heat and load conditions. (This is a production process).

Engineers currently are investigating the possibility of adhesives to fasten stiffening ribs to sheet metal panels. These researchers are thinking about the underpanels on automobile hoods and deck lids, roof supports, and truck bodies.

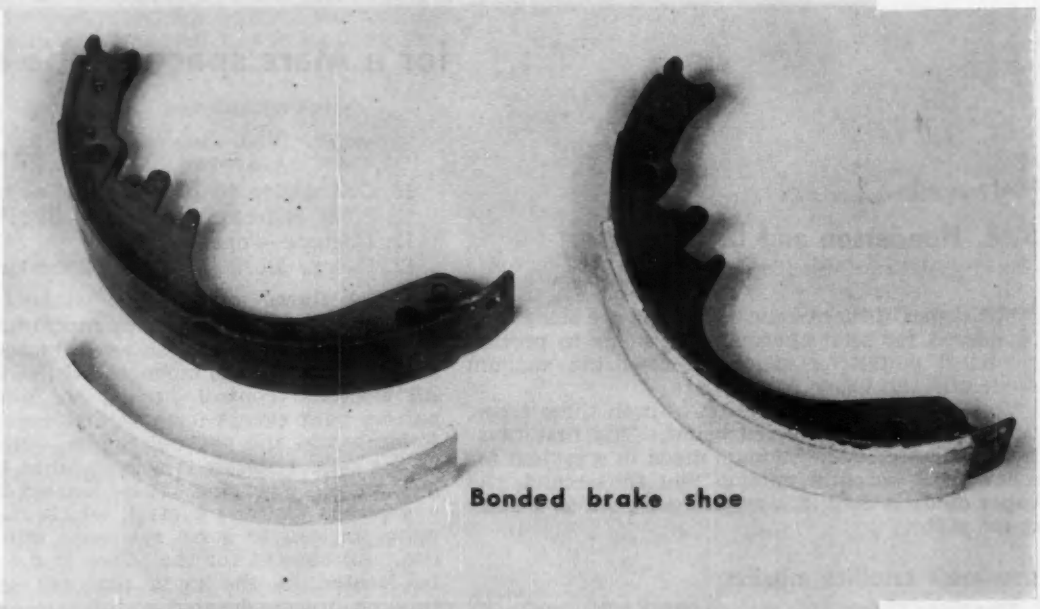
Adhesives are also being investigated for replacing bolts, rivets, and welds for fastening holders, positioners, retainers, and brackets.

New materials currently being developed for production-type structural adhesive formulations will play a part in the speed with which such investigations reach a successful adhesives-use conclusion.

To Order Paper No. 330A . . .
from which material for this article was drawn, see p. 6.



Adhesive–bonded weather seal



Bonded brake shoe

Bonded stiffener on sheet metal

Thermionic converters for space power systems

Described here is the use of the vacuum diode for a low orbit satellite mission and a vapor diode for a Mars space probe mission.

Based on paper by

R. E. Henderson and D. L. Dresser

Allison Division, General Motors Corp.

TWO types of thermionic converters are being considered for solar thermionic systems to provide electrical power for space vehicles: the vacuum diode and the vapor diode.

To illustrate the application of both these types, two systems are described below. The first illustrates the use of the vacuum diode in a system for a low orbit satellite mission. In the second, the vapor diode is used in a system designed as a Mars space probe.

Low-orbit satellite mission

The solar thermionic system using a vacuum converter has been designed to deliver up to 500 w of continuous power. A summary of the pertinent system performance and operating data is as follows:

1. Minimum orbit — 90-min orbit period; 35-min dark time.
2. Power output — up to 500 w (continuous).
3. Voltage — 28 v d-c normal (up to 29 v and down to 26 v).
4. System overall efficiency — 4.9%.
5. System weight — 340 lb.
6. Weight per unit power — 680 lb/kw.
7. Vacuum thermionic generator efficiency — 9.6%.
8. Emitter temperature — 1500 K; collector temperature — 850 K.
9. Solar concentrator — Fresnel reflector.
10. Orientation control — biaxial system ± 5 min.
11. Solar collector efficiency — 51%.
12. Lifetime — one year.
13. Energy storage — sealed NiCd batteries.

Fig. 1 shows one possible configuration. The thermionic converter and radiator are mounted on a support rod from the center of the reflector. The NiCd battery pack is mounted behind the reflector. All electrical control circuits are located in the battery pack except for a voltage regulator, which is located in the payload proper. Biaxial control of the solar reflector is accomplished by means of an arm and quadrant. It is assumed that there is a separate attitude control, which maintains the main payload to some reference other than the sun. All current for the 500-w load (presumed to be located in the main payload) is conducted through brushes located at the arm and quadrant bearing points. During launch, the reflector assembly is stored in the payload. Upon entering orbit, the reflector assembly is erected and unfolded by means of springs and hinges. A weight breakdown is given below:

NiCd battery pack	175 lb
Electrical control circuits	33 lb
Thermionic converter and radiator	44 lb
Solar reflector (all supports and the orientation control)	88 lb

NiCd Battery Pack — The battery pack consists of sixty-nine 20 amp-hr Sonotone batteries connected in a series-parallel network of 23 in series and 3 parallel groups. Under the light-dark orbit conditions and an assumed charge efficiency of 1.3 (130% of the coulomb capacity must be returned during charge), the required charging current is

17.0 amp. The battery pack is mounted in back of the reflector to maintain the temperature between 10 and 30 C. A secondary benefit of this arrangement is a reduction in the current which must pass through the bearings. If the batteries were located in the payload, it was assumed the temperature range would be −18 to +37 C. If the batteries were charged at −18 C rather than +10 C, 30% more power would be required from the thermionic converter. Hence, there is a significant saving in weight by maintaining the minimum battery temperature at +10 C.

Electrical Control Circuits — Three major control circuits are required, as shown in Fig. 2. The load voltage regulator insures that the load voltage is maintained between 26 and 29 v. This regulator is located inside the main payload. All other components are located in the battery pack behind the reflector. The battery charging current regulator regulates the current to 17 amp and also maintains the minimum temperature of the battery pack. Current drain on the thermionic converter is held constant by the TG current regulator for all load values from 0 to 500 w. Table 1 summarizes the maximum power requirements for the thermionic converter; this occurs as the battery approaches full charge with a 500-w load in the light at the end of the year.

Table 1 — Summary of Power Requirements

Source	Power Dissipated, w	Voltage Drop, v
Load	500	28.0
Load voltage regulator	35	Depends on input voltage
Leads from generator (R_1 and R_2)	10	0.3
Leads to load	2	0.1
Bearings	8	0.4
Battery charge current regulator	25	1.0
Batteries	586	34.5
Thermionic generator load regulator and filter	26	0.5
Blocking diode	9	0.5
Total	120	

Thus, the thermionic generator must supply about 1200 w of electrical power. The voltage required is the sum of the battery charging voltage and the voltage drops across the TG load regulator, the battery current regulator, and R_1 and R_2; namely 36.3 v.

Thermionic Converter — The thermionic converter and radiator configuration is shown in Fig. 3. The unit is 52 cm long and 38.3 cm in diameter to the radiator fin tips. Each fin assembly contains two parallel sets of 11 diodes connected in series. The diode design point at the end of one year is as given in Table 2.

Table 2 — Diode Design Point after One Year

Emitter Temperature, K	1500
Collector Temperature, K	850
Power Density, w/sq cm	0.865
Diode Area, sq cm	10.5
Spacing, microns	10

Each fin assembly is a separate sealed unit; therefore, in the construction and testing of the converter each fin assembly may be proof tested separately, before the six assemblies are joined together to form the cavity. The warmup time is estimated to be about three minutes.

Solar Reflector — A modified Fresnel reflector was selected for this application because the flat-plate geometry permits a certain latitude in folding

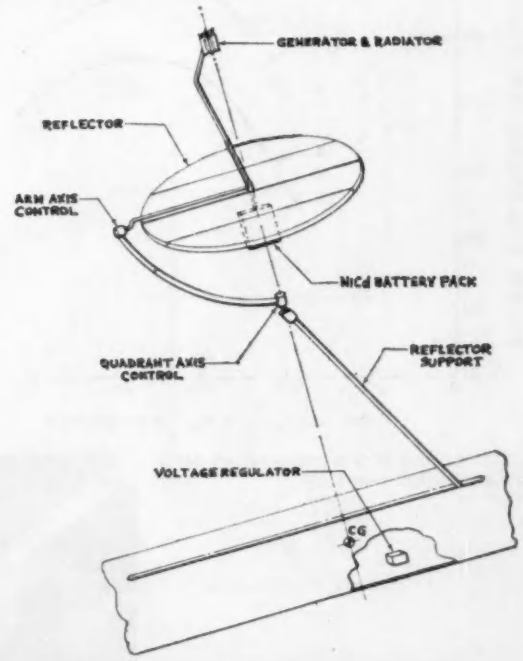


Fig. 1 — Conceptual drawing of solar thermionic system using vacuum thermionic converter. System was designed to deliver up to 500 w of continuous power for low-orbit satellite mission.

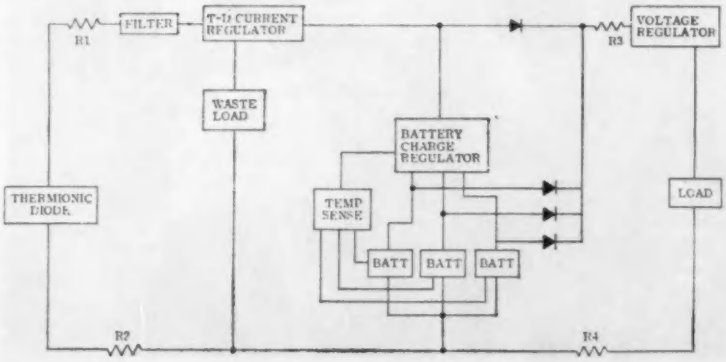


Fig. 2 — Block diagram of electrical system shows there are three major control circuits.

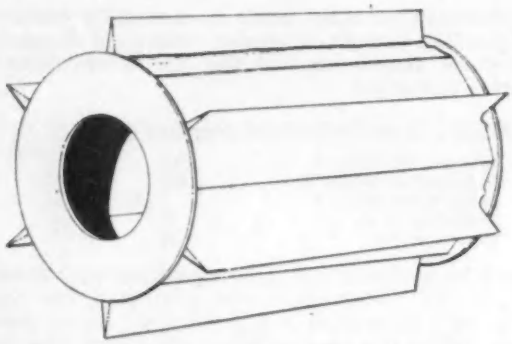


Fig. 3 — Thermionic converter and radiator configuration.

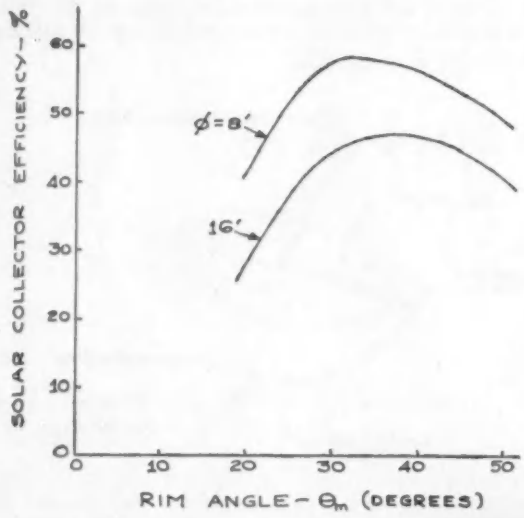


Fig. 4 — Variation of solar collector efficiency with Fresnel reflector rim angle.

designs for packaging in specific vehicles. Essentially, conical rather than paraboloidal sections are used.

The solar collector efficiency for this geometry may be expressed as follows:

$$\eta_c = \alpha_c \eta_r \eta_b T_f - \frac{\varepsilon \sigma T_K^4}{CE_s} \quad (1)$$

where:

α_c = Absorptivity of absorber
η_r = Reflectivity
η_b = Blockage factor
T_f = Fresnel useful area factor
ε = Emissivity of cavity
σ = Stefan-Boltzmann constant
T_K = Absorber temperature
C = Concentration factor
E_s = Solar constant

Equation 1, as written, can be used to compute the efficiency, assuming the absorber inlet area is made large enough to allow all of the reflected energy to enter. For this case one assumes some maximum surface error, ϕ, and computes the concentration factor by ray tracing techniques. For this design the following conditions have been assumed:

$\alpha_c = 0.95$
$\eta_r = 0.83$ (after one year in space)
$\eta_b = 0.98$
$\varepsilon = 0.95$
$T_K = 1530$ K
$E_s = 0.14$ w/sq cm

Since the factors, T_f and C, vary with rim angle, Fig. 4 shows the variation of efficiency with rim an-

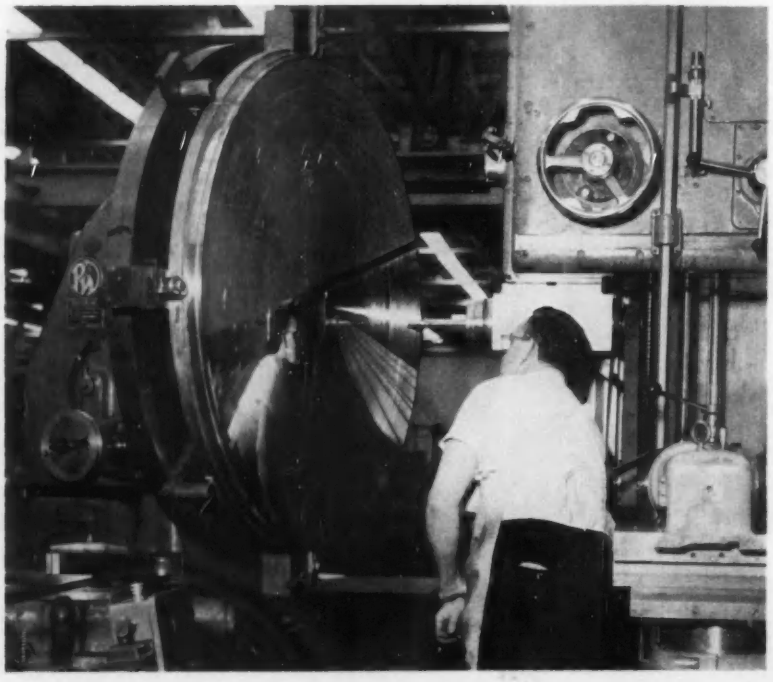


Fig. 5 — Steel pattern of 4-ft reflector of Fresnel type.

gle for a 200-serration reflector and two values of ϕ. From a consideration of the fabrication processes, assembly design, and orientation requirements, a ϕ value of 13 min was selected. Detailed calculations showed the solar collector efficiency was 51% with a rim angle of 40 deg. This allowed for the following tolerances:

Fabrication = ± 7 min
Assembly = ± 3.5 min
Orientation = ± 5 min

No attempt was made to optimize this design since experimental data were not available on the nature of the scattering distribution to be expected. A 4-ft reflector of the Fresnel type is now being fabricated for WADD. The polished steel pattern for this reflector is shown in Fig. 5. It is planned to obtain scattering data from this reflector, which should be helpful in completing optimized designs in the future. It is estimated that an optimized collector design for the 500-w system would increase the efficiency about 5%.

The reflector for the 500-w system is 4.72 m (15.5 ft) in diameter. The reflector is made in 16 sections; however, only four of these sections have different shapes, as shown in Fig. 6. In the fabrication process, accurate patterns of these four shapes are machined in steel and are then polished. A nickel foil (as thin as 0.002 in.) may then be electroplated on the pattern. While the foil is in place on the pattern, a rigid structure of nickel wire screen and nickel foil is attached with an adhesive. Fig. 7 shows the reflector assembly design. The assembly is removed from the pattern and the foil ultrasonically welded to the backup structure. The bonding adhesive is then removed by heating at 60 C. The ultrasonic joining method adds negligible weight to the reflector. The nickel surface is vacuum-plated with aluminum to a thickness of about 600 A and a silicon monoxide coating is added to protect the reflector surface during test and evaluation. The areal density of the reflector is 0.385 psf. Mounting supports account for the remaining weight.

An analysis of the thermal distortion for the Fresnel structure shows that the transient temperature rise in the foil at satellite dawn is essentially complete in 120 sec; however, the temperature rise in the box beam support structure lags considerably, due to the comparatively large thermal inertia. By using an all-nickel construction different differential expansion rates are avoided, but this does not completely solve the problem. An analytical solution to give the reflector optical performance as a function of time after satellite dawn was not completed. The complexity of the problem requires that simplifications and gross assumptions be made in order to reach a solution — even then, the validity of such a solution is questionable. It is planned to obtain experimental data on the 4-ft reflector to clarify further the nature and magnitude of this problem. Orientation is accomplished by a biaxial control system. The basic features of the control are shown in Fig. 8. Coarse sensors provide rough alignment, while a set of fine sensors surrounding the absorber inlet area are used to obtain the high pointing accuracy. By using the fine sensor concept it is not necessary to obtain precision positioning of the cavity absorber in the reflector focal plane. The combined sensor error signal is amplified in a solid-state amplifier and the output powers a small d-c servo motor. The standby is estimated to be 10 w.

Space probe mission

The Mars fly-by probe, designated Mariner B, will be assumed for this design, since a solar thermionic system is now being considered for this mission. The raw power required is considered to be 350 w at Mars. In the following discussion there is no detailed description of a packaging design or erection method. Rather, the major design considerations will be presented and some of the development problems pointed out, because the mission requirements for a Mars space probe are quite different in many ways from those for an earth satellite.

It is assumed that the outside diameter of the payload is 10 ft at the base. The power system consists of four one-piece paraboloidal reflectors 4.5 ft in diameter, and four single-diode 97.25-w vapor thermionic converters connected in series. The out-

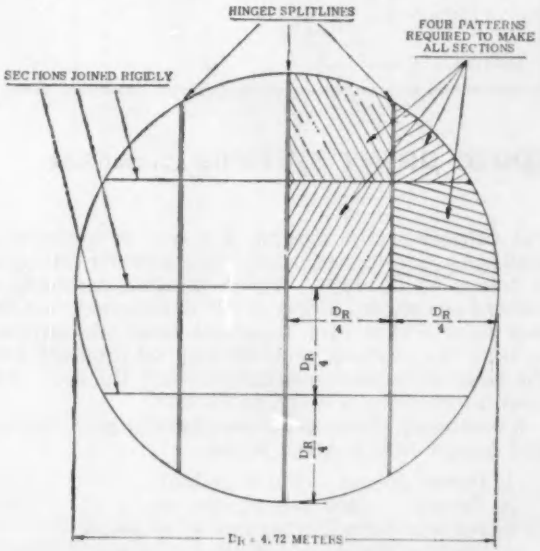


Fig. 6 — Sections of solar reflector.

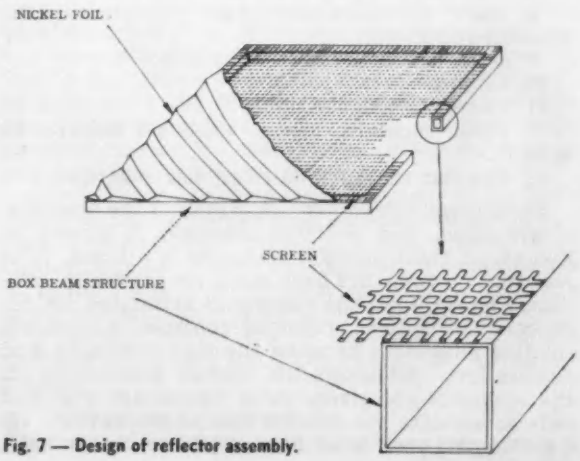


Fig. 7 — Design of reflector assembly.

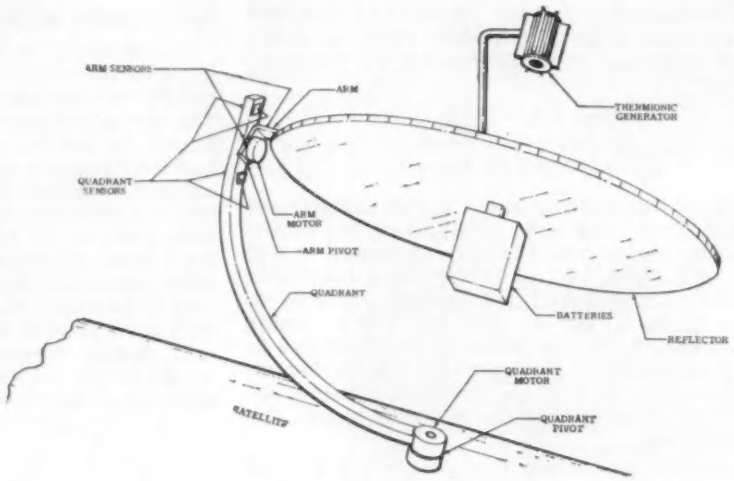


Fig. 8 — Orientation control.

space power systems ... continued

put voltage of the system, 4 v d-c, is inverted to 2400 cps a-c for distribution. The inverter efficiency is taken to be 90%. Three possible methods of storage are shown in Fig. 9. It is assumed that the last stage rocket case separates from the payload, so that the payload package may be oriented with the base of the cone pointing toward the sun. The orientation error is taken as ± 5 min.

A summary of the pertinent system performance and design data is given below:

1. Power output — 350 w at Mars.
2. Voltage — 2400 cps square wave.
3. System overall efficiency — 10.2%.
4. System weight — 108 lb.
5. Vapor thermionic generator efficiency — 18%.
6. Emitter temperature — 1900 K; collector temperature — 1000 K.
7. Payload pointing accuracy — ± 5 min.
8. Solar concentrators — four one-piece paraboloidal reflectors.
9. Solar collector efficiency — 63%.
10. Lifetime — trip to Mars.
11. Energy storage — none.
12. Solar constant (mean value at Mars) — 54 w/sq ft.
13. Angular measure of solar disc — 21 min.

Thermionic Converter — A sketch of the absorber, single-diode, and radiator assembly is shown in Fig. 10. A right cylinder geometry is utilized. The absorber opening has been sized for maximum efficiency based upon the tolerances estimated for reflector fabrication, reflector-absorber alignment, relative alignment between the four reflectors, and orientation. Although the overall dimensions on the assembly are given, these figures are intended only to indicate the general size of the device. No detailed analyses have been made to obtain such information as the temperature distribution along the inner surface of the absorber, the minimum radiator weight, or a verification that the design temperature on the cesium reservoir can be achieved with the dimensions shown. The pertinent design data for the converter are estimated as follows:

1. Power output — 97.25 w.
2. Power density — 4.15 w/sq cm.
3. Emitter area — 23.5 sq cm.
4. Output voltage per converter — 1 v.
5. Emitter temperature — 1900 K.
6. Emitter material — molybdenum.
7. Collector temperature — 1000 K.
8. Collector material — titanium.
9. Radiator material — copper.
10. Electrode spacing — 0.005 in (127 microns).
11. Cesium reservoir temperature — 575 K.

It is estimated that the converter will weigh between one and two pounds, and have an efficiency of 18%. This is a "device" efficiency that accounts for conduction and radiation losses on this particular design.

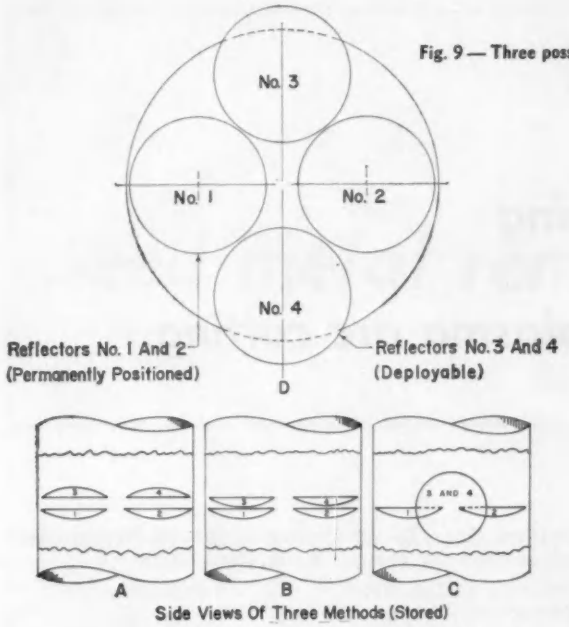
Solar Concentrator — The solar concentrator is a paraboloid with a rim angle of 54.9 deg and a 4.5-ft diameter. The following performance figures are estimated:

$$\alpha_o = 0.98$$
$$\eta_r = 0.90$$
$$\eta_b = 0.99$$
$$\varepsilon = 0.98$$

$T_K = 1900$ K (negligible temperature gradient across the emitter)

For this design a uniform scattering distribution is assumed — however, it would be more correct to assume a normal distribution. Since the major purpose of this discussion is to indicate the design

Fig. 9 — Three possible methods of storage.



Side Views Of Three Methods (Stored)

procedure, the exact nature of the scattering errors is of secondary importance. It can be said that the uniform scattering distribution will yield a conservative result, assuming equivalent surface error limits, when compared to a normal distribution.

A high-quality glass searchlight reflector will have maximum angular errors in the neighborhood of one minute. In the fabrication of the 4.5-ft diameter paraboloids, an Army surplus 5-ft diameter glass searchlight reflector would be used as the pattern to electroform nickel one-piece reflectors. The outer area would be masked off to give the design diameter and rim angle. It is estimated that fabrication, erection, and relative alignment errors would be equivalent to a ϕ of 6.9 min. Accounting for the blockage, and cavity absorptivity and emissivity, the solar collector efficiency is calculated to be 63% at Mars. At earth the optimized collector efficiency will be somewhat higher, about 70%.

The thermionic converter would be positioned by means of a telescoping arm and guy wires. The reflector thickness is 0.020 in., with a thicker rim for support. The exact weight of the reflector support would depend upon the specific storage and erection design. The total weight is estimated to be 1.55 psf or 25 lb per assembly.

The total system weight is estimated to be about 108 lb or 325 lb/kw at Mars. This is roughly equivalent to the present solar cell performance at earth — the solar cell performance at Mars would be about 1000 lb/kw. Thus, the thermionic system is seen to be potentially lighter in weight than solar cells. Even more important is the consideration of cost. Some estimates have been made that solar cells cost approximately one million dollars per

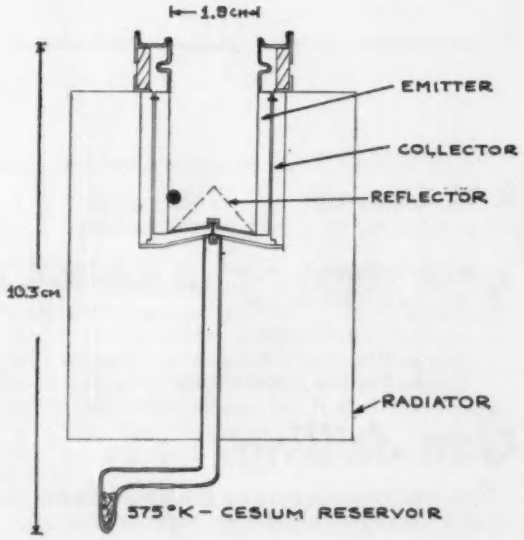


Fig. 10 — Design for solar thermionic vapor converter.

kilowatt in an earth orbit. The thermionic system promises significant reductions in this cost.

Other Considerations — Four single-diode converters are used in this system. It is assumed that the inverter efficiency of 90% may be obtained with a 4-v d-c input. Thus, some cooling method is assumed available to maintain the transistor temperature below 60 C. If it is not possible to maintain the temperature below 60 C, then it is imperative that a multidiode converter be designed for each module, since the inverter efficiency using silicon transistors is quite low at low input voltages. This probably means a lower device efficiency and a potential loss in system reliability.

Finally, near the earth the heat input to the converter will be about two and one-half times the design value at Mars. This means that some type of heat input control must be included on each module to protect the converter and maintain a constant power output. Such approaches as a variable aperture on the heat cavity or defocusing the whole converter vertically along the optical axis are possibilities.

To Order Paper No. 350C . . .
from which material for this article was drawn, see p. 6.

gun drilling

hot machining

plasma arc cutting

Based on report by secretary

R. N. Ciccarelli
General Electric Co.

STOCK REMOVAL of high-temperature alloys can be increased by:

1. Gun drilling
2. Hot machining
3. Plasma arc cutting

Gun drilling

The advantages of using the gun drill for production of the deep holes in the super alloys are:

- A close-tolerance hole may be produced from the solid in one pass — eliminating the secondary operations of reaming and honing.
- Holes may be produced that are straight within 0.002 in. per ft.
- Finishes of 15 microin, are consistently attainable, and less in some applications.

The gun drill consists of a hollow shaft rolled from tubular steel to form a flute. The cutting tip, usually of carbide, is brazed to the shaft and ground concentric with a suitable holding adaptor. The single cutting edge is guided by integral wear pads as the cutting takes place. A hole or oil passage runs longitudinally through the shaft.

The gun drill is fed at light feed rates — ranging from 0.0001 in. per rev to 0.001 in. per rev — into the workpiece. Speeds for gun drilling super alloys are 10–15 sfpm. As the gun drill is fed into the work, coolant is forced under high pressure through the oil passage in the drill shank so that the coolant is applied directly to the cutting edge of the drill. This serves a dual purpose. First, it cools both the drill and work where the cutting occurs, and secondly, the coolant forces the metal chips back through the flute and away from the cutting area.

Coolant pressure requirements vary with hole size and depth, but there must be sufficient flow to eject the chips while cooling and lubricating the cutting tips. In development, the maximum pressures used for various holes have been:

Diameter	Pressure
0.250 in.	1500 psi
0.187	2500
0.125	3000
0.093	3000

Since gun drilling setups recirculate the coolant (which is under high pressure for long periods), it is necessary to cool the oil. Normal methods of water cooling or refrigeration may be used. Removing heat from the coolant prevents vapor lock in the high pressure pump, maintains the viscosity of the coolant, and prevents thermal expansion of the work from affecting the size of the hole.

Metal particles are removed from the coolant by a filter — capable of removing particles of 5–10 microns. Filtration serves to protect the pump and to prevent recirculation of metal particles past the drill point.

Gun drilling equipment is both of the horizontal and vertical type. Inverted vertical drilling is sometimes used.

On small diameter holes — such as 0.093 in., by mounting the drill in a stationary vertical position and by rotating and feeding the workpiece into the drill, removal of chips is aided significantly by gravity.

Hot machining

Comparative machinability tests have recently been conducted at room temperature and at elevated temperatures on various materials. Temperatures in the 800–900 F range on materials such as SAE 4340 steel, Thermold J, 17–4 Mo, and Rene 41 at 380–600 Bhn have resulted in tool life improvements over room temperature of 4–100 times. Or, for a given tool life, the hot machining approach has resulted in increases of 33–700% in metal removal rates when milling or turning.

Experimentation has demonstrated that tool life varies inversely with the 20th power of the tool-chip

speed metal removal

interface temperature (in deg C) when the workpiece is at room temperature. At higher tool temperatures, the tool material is more readily abraded away. Thus one would anticipate that increasing the workpiece temperature would have the negative effect of decreasing tool life. However, there is another important factor which affects tool life — the ability of the work to abrade the tool. At higher workpiece temperatures, this ability becomes lessened, and has the positive effect of increasing tool life.

So, through selection of the proper workpiece temperature the inability of the work to abrade the tool could outweigh the abrading of the tool material due to the higher tool-chip interface temperature. At this properly selected temperature, the net effect is increased tool life.

Various methods for heating the workpiece have been evaluated. Radio frequency resistance heating has proved most satisfactory for magnetic materials. R-f resistance heating concentrates the heat, minimizing workpiece distortion and metallurgical damage. For nonmagnetic materials, inert tungsten arc heating provides a good concentration of heat for both depth and area. The selection of these two methods over others is for their ability to provide localization of heat in just the area of machining. Heating the complete workpiece to high temperatures for a long time would result in loss of hardness, tempering, and distortion of the workpiece.

Plasma arc cutting

Plasma are cutting utilizes the basic principle that an ionized gas is conductive and thus may be kept at the high ionization temperatures by electric current.

In the plasma arc torch, a gas under high pressure passes through an electric current, becomes heated and ionizes. The heated ionized gas, remaining at the high ionization temperature by continual passage of electric current through it, flows then through a nozzle constriction. A high-temperature plasma jet emanates from the nozzle. It is this plasma jet which is used for metal cutting.

Plasma arc torches are of two basic designs:

1. Transferred arc
2. Nontransferred arc

The transferred arc torch is considered more effective for metal-cutting application. In this design, the current flow travels a path from a tungsten electrode (cathode) through the gas to the workpiece (anode) to ground. The plasma jet is at its highest temperature at the point of cutting.

In the nontransferred arc torch the flow of current is from the tungsten electrode (cathode) through the gas and back through the nozzle (anode).

Gases normally used in the plasma arc torches include argon, hydrogen, and nitrogen. Nitrogen is sometimes avoided though as toxic nitrogen oxides may be formed.

Temperatures attained in the transferred arc torch may be illustrated by the following typical application. Argon gas, flowing at 40 cu ft per hr, ionized by a current of 200 amp at 29 v, and subsequently passing through a 3/16 in. diameter nozzle will result in a high velocity plasma jet at a temperature of 24,000 K. Under the same conditions, the use of hydrogen instead of argon will result in a slightly higher plasma jet temperature and much higher jet velocities.

Plasma arc torches have been successfully used for cutting aluminum and stainless steel up to 4 in. thick. Magnesium and copper have been successfully cut to lesser thicknesses.

The primary advantage of the plasma arc process lies in the high rate of cutting — which may run 100 in. per min on ½-in. thick aluminum.

Quality of the cut surface is quite good and it is possible to weld pieces in the as-cut condition.

The heat-affected zone is dependent on the thickness of material and the rate of cut. However, with stainless the original hardness of the material will remain within 1/16 in. of the cut face and no carbide precipitation will be found in the cut face.

Based on report of panel discussion on Stock Removal — R. D. Halverstadt, chairman.

M.I.T. develops engine for friction and wear studies

Based on paper by

A. R. Rogowski
Massachusetts Institute of Technology

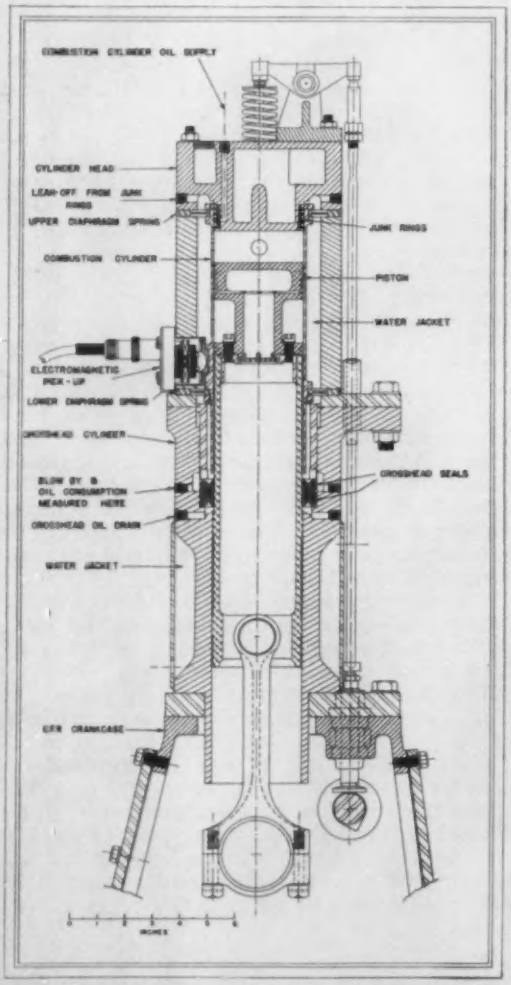


Fig. 1 — Engine, showing crosshead and spring-mounted combustion cylinder.

RESEARCH on friction and wear in engines can be performed very effectively on an engine cylinder specially designed to measure, at any crank angle, the instantaneous value of the friction force between piston rings and cylinder wall under normal firing conditions. If desired, the friction force between the entire piston assembly and the cylinder wall can also be measured.

Cylinder and crosshead assembly

Fig. 1 shows the special cylinder and crosshead assembly mounted on a CFR engine crankcase. Measurement of instantaneous friction forces is made possible by elastically mounting the light combustion cylinder sleeve so that friction forces between the sleeve and the piston rings produce small movements of the sleeve parallel to its axis. This motion is detected electrically and recorded with camera and oscilloscope.

The cylinder sleeve is clamped on the inner circumferences of two annular steel diaphragm springs by means of threaded rings on the cylinder. The outer edge of the upper diaphragm is clamped between the cylinder head and an outer cast-iron cylinder barrel, and the lower diaphragm is clamped between the outer cylinder barrel and a steel base plate by means of through bolts. As the sleeve motion is measured at a point near the point of attachment of the lower diaphragm, most of the stiffness of the system is supplied by this diaphragm in order to minimize errors due to thermal expansion of the sleeve. The natural frequency of the sleeve is 1100 cps and the spring rate of the sleeve is 815,000 psi. The space between the sleeve and outer cylinder barrel serves as a water jacket, and is kept full of water by bleeding any air or steam out through small holes just under the upper diaphragm.

Two spark-plug wells are attached to the cylinder sleeve and sealed by rubber gaskets, which exert negligible axial constraint on the sleeve.

The cylinder head (Fig. 2) contains the normal valves and ports but presents a problem of sealing in the cylinder gases without introducing axial forces on the sleeve. This problem was solved by using four unsplit (continuous) junk rings (Fig. 3) fitting into the top of the cylinder sleeve with a diametrical clearance of 0.002 in. The junk rings are held in the head and spaced by spacer rings, allowing ample radial and axial motion of the junk rings so that they can align themselves with the cylinder sleeve and move with it in their grooves. The lands between the junk rings have a diametral clearance within the cylinder sleeve of 0.010 in., insuring no contact with the sleeve. Lubricating oil supplied under pressure to the junk rings forms an effective cylinder gas seal. Vent holes are provided in the cylinder head to allow oil and gases that leak past the junk rings to escape and thus avoid a rise in pressure above the upper diaphragm. Most of the oil supplied to the junk rings escapes through these vents, but by proper adjustment of metering pressure, a minute quantity will enter the combustion space and provide cylinder wall lubrication. The proper oil supply to the junk rings (about 2 cc per min) must be determined by experience and is rather critical, as too much will cause carbon in the cylinder, and too little will cause deposits on the junk rings due to gas leakage. The cylinder head is kept cooler than normal (65 F) by flowing cold water through its jackets in order to eliminate junk ring sticking and to keep the oil viscosity at the junk rings high.

When it is desired to measure the friction force of rings only, the water jacketed crosshead cylinder shown in Fig. 1 is installed between the CFR crankcase and the upper cylinder assembly. An aluminum-alloy crosshead (shown in Figs. 1 and 4) operates in this cylinder and carries on its upper end a special piston, which is shown in detail in Fig. 5. The lower part of the piston is reduced in diameter to save weight. The design of crosshead and piston is such that, during engine operation, only the piston rings touch the combustion cylinder

M.I.T.'s Sloan Automotive Laboratories have designed a special engine cylinder to measure the instantaneous friction of piston rings in a firing engine, as described in the accompanying article.

Some of the results obtained with this apparatus, when used on short projects and for a limited number of operating conditions and ring and cylinder materials, are given below:

- Maximum feasible ring tensions caused barely detectable increases in total piston friction work.
- Wide rings gave only slightly greater friction than narrow rings.
- Removing the lower two of three narrow rings caused little change in fmep, while the removal of the lower two of three wide rings caused a reduction in fmep of about 25%.
- Ring friction tended to decrease with running time, with most of the change occurring during the first hour.
- Ring friction increased with engine speed, decreased with cylinder jacket temperature, and the piston-ring fmep increased about 1 psi for each 6 psi increase in inlet manifold pressure.
- Piston and ring friction were not increased under severe conditions of detonation, or when ring scuffing was induced by the use of ethylene glycol.
- Ring friction was greater during the compression and expansion strokes, and less during suction and exhaust.
- Discontinuities in the friction force records indicate metallic contact and static friction and breakway conditions at top and bottom center. In Fig. 7 may be seen the effect of inlet pressure and engine speed on the magnitude of the friction forces. The effect of inlet pressure on breakaway friction is particularly noticeable.

Fig. 2 — Cylinder head, showing junk rings.

M.I.T. develops engine for friction and wear studies

. . . continued

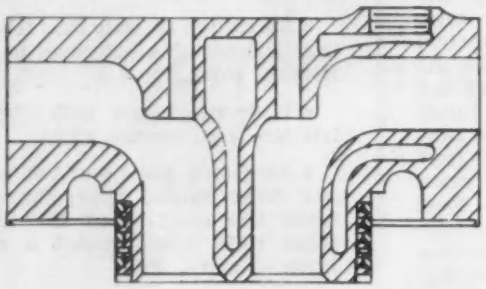
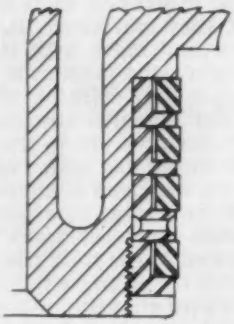


Fig. 3 — Junk ring assembly, showing method of retention.



Enlarged section of ring assembly

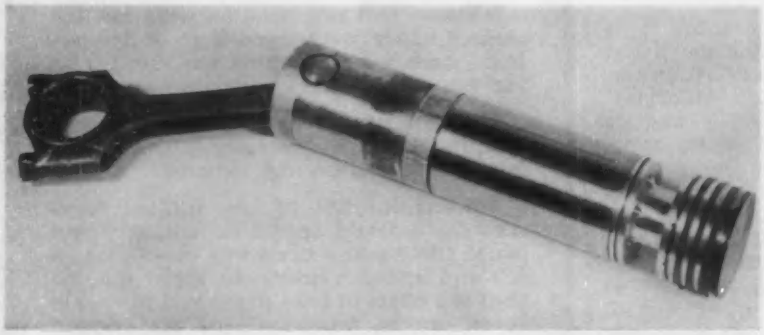


Fig. 4 — Assembly of connecting rod, crosshead, and piston.

Fig 5 — Pistons for study of wide and narrow rings.

sleeve. The outer barrel, containing sleeve, diaphragms, spark-plug wells, and pickup unit, is shown in Fig. 6.

Two oil seals are installed below the combustion cylinder. The upper seal prevents the oil and gas that leaks past the piston rings from escaping into the crankcase. These products are led out through passages above the seal and may be measured. The lower seal helps to prevent the crankcase oil from contaminating the oil supplied through the junk rings to the combustion cylinder. Oil caught by the lower seal is returned to the crankcase.

To detect the very small axial motions of the cylinder, an electromagnetic pickup was designed with two coils, whose magnetic air gaps are affected in opposite directions by the movement of an armature attached to the cylinder sleeve. This pickup is connected to an impedance bridge circuit using a 5000-cps carrier. The edge of the modulated carrier is photographed to give a record of the sleeve motion. Examples of records of this sort are shown in Fig. 7. To obtain these records the oscilloscope sweep is turned off and a strip camera is used. In the strip camera, about ten feet of film is drawn at constant velocity by means of a synchronous motor, past an open lens focused on the scope screen.

Overall calibration of the cylinder sleeve spring system and the electrical measuring apparatus is relatively easy to accomplish by loading the sleeve with test weights.

To Order Paper No. 379F . . .
from which material for this article was drawn, see p. 6.

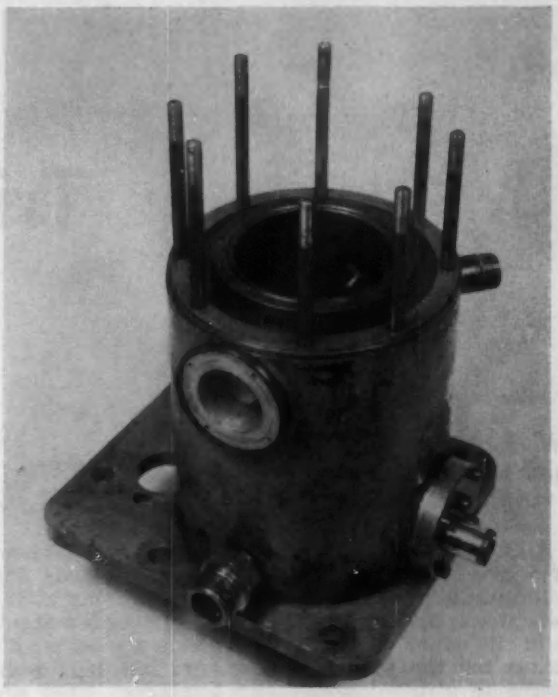


Fig. 6 — Cylinder barrel, showing spark-plug well.

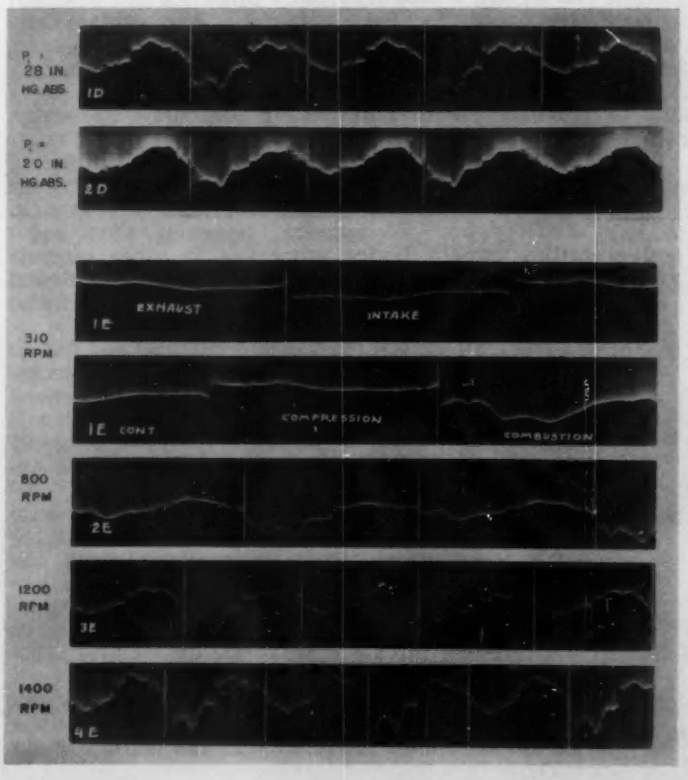


Fig. 7 — (Upper view) effect of manifold pressure on piston-ring friction. (Lower view) effect of engine speed on piston-ring friction.

Trisonic transports

Based on paper by

W. F. Brown, Jr., G. B. Espey, and M. H. Jones
NASA Lewis Research Center

ALLOY types having potential application as sheet materials for trisonic transports include the titanium alloys, the precipitation-hardening stainless steels, the metastable austenitic stainless steels and the super alloys. These metals are all candidates for the job that aluminum has long been doing in airplane wings and fuselages. They are needed because the service conditions which will accompany Mach 3 flight are too severe for aluminum. Temperatures between 500–600 F for times up to 30,000 hr, the useful life of the aircraft, are anticipated. Fortunately the mechanical properties of the materials in the above groups may be varied over wide limits by suitable heat treatment and/or cold working procedures. Tensile strength to density values of over 800,000 are easily obtained. This compares to a maximum of about 700,000 characteristic of presently used Al alloys. They may all be fabricated by methods already available to the industry although, in some cases, special precautions are necessary.

Representative materials from these classes of alloys are listed in Table 1, along with their nominal compositions. To make a suitable selection for the intended application, a large number of factors must be considered. The conventional tensile properties serve as a base line for evaluating the different classes. Other things of concern are: resistance to catastrophic fracture in the presence of a long crack, resistance to brittle crack propagation, toughness, creep, stress corrosion, and fatigue crack growth.

Table 1.

Alloy	Class	C	Cr	Ni	Co	W	Mo	Cb+Ta	Al	V	N_2	Fe	Ti
8Al-1Mo-1V	Titanium	--	--	--	--	--	1.0	--	8.0	1.0	--	--	--
6Al-4V		--	--	--	--	--	--	--	6.0	4.0	--	--	Bal.
13V-11Cr-3Al		--	11		--	--	--	--	3.0	13	--	--	Bal.
AM 350	Precipitation Hardening Stainless Steels	0.10	16.5	4.5	--	--	3.0	--	--	--	0.10	Bal.	--
AM 355		0.125	15.5	4.5	--	--	3.0	--	--	--	.10	--	
AM 355		0.135	15.5	4.5	--	--	3.0	--	--	--	.10	--	-
17-7-PH		0.09 max	17	7	--	--	--	--	1.75	--	--	Bal.	-
PH15-7Mo		0.09 max	15	7	--	--	2.5	--	1.0	--	--	Bal.	-
AISI 301	Metastable Austenitic Stainless Steel	0.15	17	7	--	--	--	--	--	--	--	Bal.	--
A-286	Super Alloys	0.08 max	15	26	--	--	1.25	-	--	--	-	Bal.	2.0
V-36		0.30	25	20	Bal.	2.0	4.0	2.0	--	--	-	5 max	-
Rene 41		0.10	19	Bal.	11	--	10	--	1.7	--	--	5.0	3.0
D979		0.05	15	45	-	3.75	3.75		1.0	-	-	Bal.	3.00

Tensile properties

APPEARING in Fig. 1 are the ultimate and 0.2% yield strength of these materials, in the temperature range of interest. It is seen that of the Ti alloys, the aged β offers the highest strength. However, this alloy condition has serious limitations in other important areas, such as embrittlement. The new α alloy was designed for high strength at moderate temperature. All of these alloys have yield strengths that drop rapidly at temperatures over 800 F. Interstitial elements such as O_2, N_2, C and H_2 greatly influence the strength and ductility of these materials. Also, surface contamination during heat treatment is to be avoided.

The precipitation-hardening stainless steels may be strengthened in the annealed condition by a number of different heat treatments. Generally, the highest strengths are obtained by either cold-rolling or subzero cooling, followed by tempering. Combinations of subzero treatment and cold work have been used to obtain very high strengths in some cases. It appears, however, that equal strengths but better properties in other respects can be obtained through cold work alone followed by tempering. (Tempering produces additional strengthening by an aging mechanism.)

The AISI 301 XH (65% cold reduction) is a typical metastable austenite which transforms to martensite during cold rolling. Its properties depend strongly on the amount and temperature of cold reduction. While this particular alloy has a rapidly diminishing yield strength above 800 F it has excellent properties in other respects.

The super alloys must be cold worked to gain high strength, the response to cold work varying with composition. High temperature aging can add further strength in some cases. These alloys offer superior strength at elevated temperatures. It is evident from Fig. 1 that the yield strengths do not decrease rapidly until temperatures over 1100–1200 F are reached.

The strength to density ratios of the strongest as well as the more commonly-used alloys from these groups are shown in Fig. 2. The low density of the

need better metals

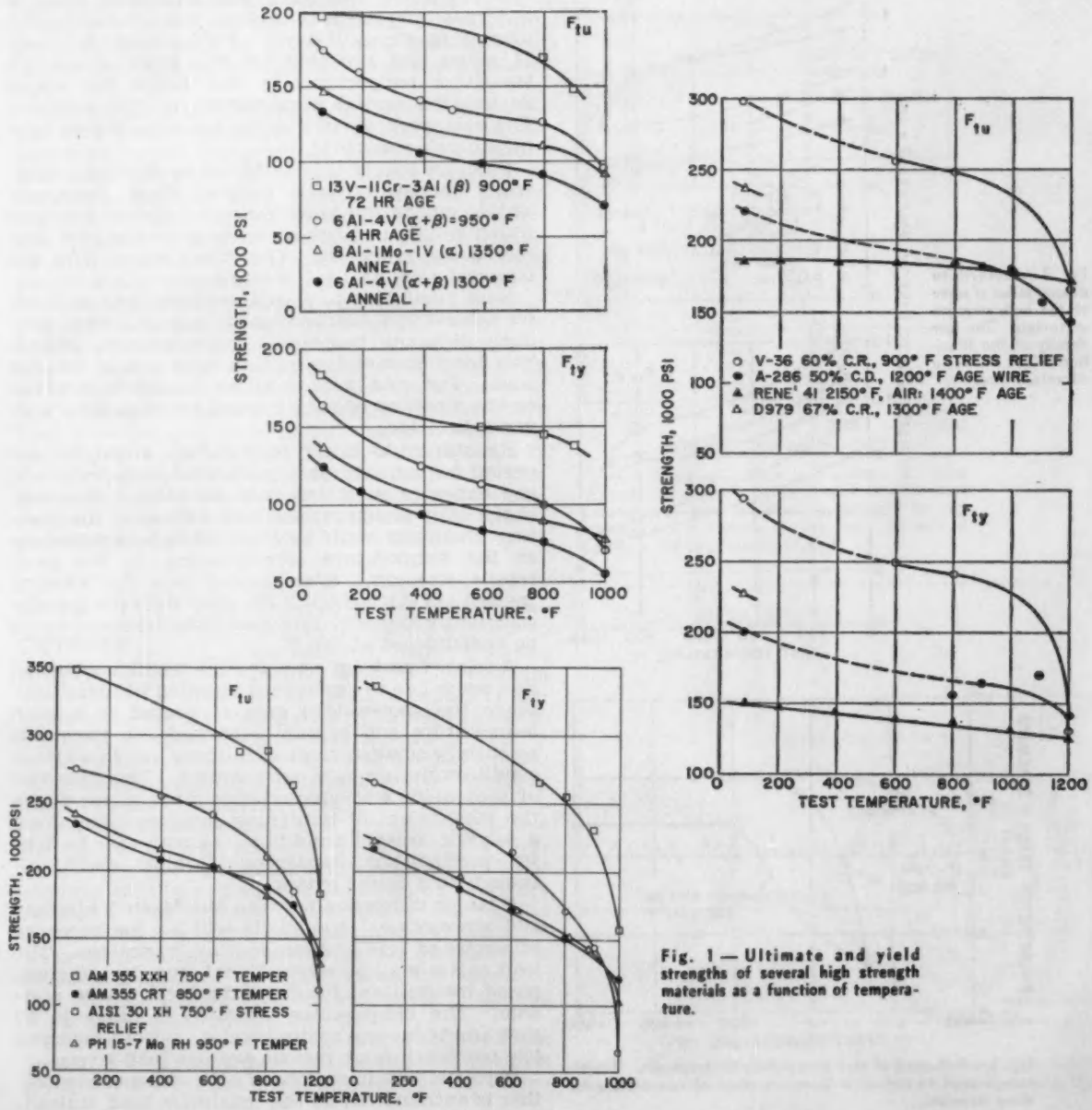

STRENGTH, 1000 PSI
F_{tu}
F_{ty}
□ 13V-11Cr-3Al (β) 900° F 72 HR AGE
○ 6Al-4V (α+β)=950° F 4HR AGE
△ 8Al-1Mo-1V (α) 1350° F ANNEAL
● 6Al-4V (α+β) 1300° F ANNEAL
TEST TEMPERATURE, °F
○ V-36 60% C.R., 900° F STRESS RELIEF
● A-286 50% C.D., 1200° F AGE WIRE
▲ RENE' 41 2150° F, AIR: 1400° F AGE
△ D979 67% C.R., 1300° F AGE
□ AM 355 XXH 750° F TEMPER
● AM 355 CRT 850° F TEMPER
□ AISI 301 XH 750° F STRESS RELIEF
△ PH 15-7 Mo RH 950° F TEMPER

Fig. 1 — Ultimate and yield strengths of several high strength materials as a function of temperature.

Ti alloys gives them an advantage here. The significance of this comparison largely depends on such factors as elastic properties and hardware geometry.

Crack propagation

RESISTANCE to the several modes of crack propagation is essential in this application. A completely crack-free structure is seldom realized even using the best fabrication techniques, nor are scratches avoidable in service. Even if cracks were not present there is the chance that static and fatigue loading at points of stress concentration will exhaust local ductility and produce cracks during service.

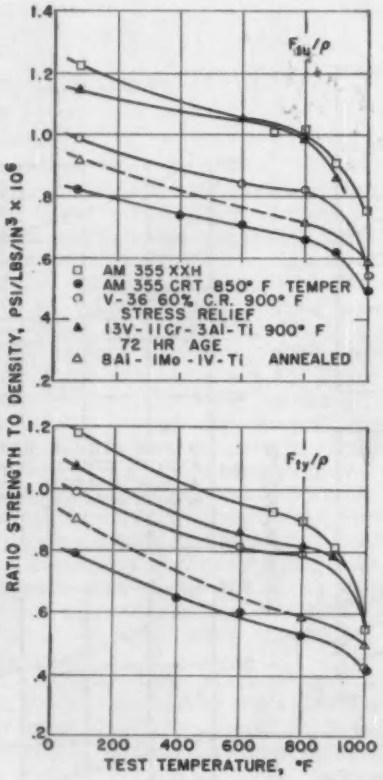

RATIO STRENGTH TO DENSITY, PSI/LBS/IN³ x 10⁶
F_{tu}/ρ
F_{ty}/ρ
AM 355 XXH
AM 355 CRT 850° F TEMPER
V-36 60% C.R. 900° F STRESS RELIEF
13V-11Cr-3Al-Ti 900° F 72 HR AGE
8Al-1Mo-1V-Ti ANNEALED
TEST TEMPERATURE, °F

Fig. 2 — Strength to density ratios of some of the high strength materials. The low density of the titanium alloys shows to advantage here.

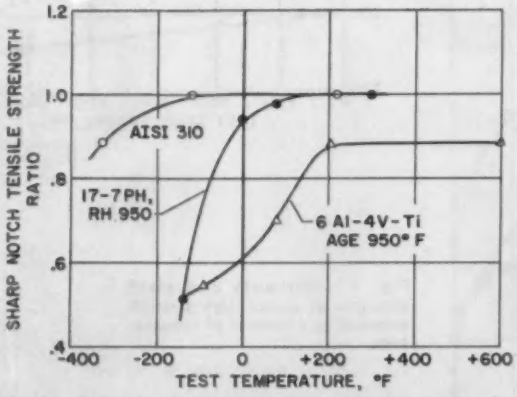


Fig. 3 — Influence of test temperature on toughness. Toughness is seen to reduce in a narrow range of temperature for these materials.

There are two phases of crack growth — stable and unstable. Stable crack growth occurs under static or alternating loads and will cease if the loads are sufficiently reduced. As the stable crack extends, it may eventually reach a length where the elastic energy stored in the structure can cause unstable (catastrophic) growth regardless of the external load. For some high-strength materials crack lengths of only a few hundredths of an in. will produce catastrophic fracture at average stresses less than 25% of the tensile strength.

Some steels and heat treated Ti alloys decrease in toughness within a narrow range of decreasing temperature. This effect is shown in Fig. 3, where the sharp notch tensile strength is used as a fracture toughness indicator. The transition range is generally displaced to higher temperatures with increasing strength level. Fortunately, for most Ti alloys and probably for the super alloys the transition temperature is well below the lowest anticipated service temperature of the airplane. The cold worked super alloys are expected to have high crack resistance.

Fracture toughness is affected by thickness, generally increasing with reduced sheet thickness. This is due to the lower degree of plastic restraint which results in large amounts of plastic flow preceding the crack tip. The effect varies with the material and its heat treatment.

Heat treatment and cold working, two methods for achieving a required tensile strength level, produce different toughness characteristics, Fig. 4. The tougher metal condition is produced by cold work. For cold worked alloys toughness depends on the direction of rolling, being lower in the transverse direction.

Resistance to crack propagation might be expected to increase at a particular temperature if the exposure produces only softening. However, if the alloy is strengthened by exposure, the fracture toughness would be expected to be a minimum at the temperature corresponding to the peak tensile strength. Some recent data for solution treated 13V–11Cr–3Al–Ti (β) alloy indicate that for sufficiently long exposure time embrittlement would be encountered at 500 F.

A related problem concerns the possible effect on spot welds due to exposure at elevated temperatures. Since the spot-welded area is heated to a high temperature and rapidly quenched the nugget is essentially solution treated and may age to a brittle condition during long time service. This behavior of spot welds may characterize other alloys where the mechanism of hardening involves aging from a solution treated condition. It may also be true for precipitation hardening stainless steels, although to a lesser extent.

A major difference between the Mach 3 airplane and conventional transports will be the presence of combined load and temperature variations. The load cycles may be conventional, but the superimposed intermittent heating introduces a new variable. The temperature variation is likely to be slow and to involve holding periods at both high and low temperature at various average load levels.

If plastic flow in regions of high stress concentration is encountered at the maximum load, unload-

ing while the temperature is maintained will result in compressive stresses. Compressive plastic flow may take place. Repeated cycles of this type can cause a crack to form which may then propagate by the same mechanism. This effect might be accelerated if the alloy is metallurgically unstable at the operating temperature so that precipitation accompanies the plastic flow and reduces the local ductility. Effects of this nature can be expected to influence the crack propagation characteristics under simple loading and unloading conditions as well as under alternating loads.

The rate of fatigue crack propagation produced by alternating loads increases with the tensile strength and with decreasing fracture toughness of Ti sheet alloys.

For intermittent heating it might be expected that under conditions of sustained load only the time at the maximum temperature would be of importance. Of course where thermal stresses are produced they must be added to the load stresses. If they are sufficiently high they may cause plastic flow.

In some cases the damaging effects of both varying load and temperature, acting singly, can be combined to get the effect of their acting simultaneously. Suppose, as in Fig. 5, the airplane is subjected to some load variation during steady supersonic operation, with the temperature remaining essentially constant and high. This is represented by period A. A crack, once initiated, may extend slowly due to the fatigue loads. It is, however, well below the critical size for catastrophic propagation at the elevated temperature. When the airplane decends, though, (period B), crack growth ceases due to increased strength with decreasing temperature, but critical crack size also drops with temperature. If turbulent air should produce large load variations, as in period C, crack growth can start again at the relatively low temperature. If the fracture toughness is sufficiently low only a small amount of additional crack extension will be required to reach the critical crack size and produce catastrophic failure.

Stress corrosion and creep

STRESS corrosion is not a new problem and certain aluminum alloys are subject to cracking in salt environments. However, the problem in the Mach 3 transport airplane is increased in complexity by increased susceptibility at elevated temperatures and the possibility of decreased corrosion resistance which may accompany metallurgical instability produced by very long time exposure. Generally, both the precipitation hardening stainless steels and the titanium alloys are subject to stress corrosion cracking in the presence of sea salt at elevated temperatures, while the straight stainless steels and super alloys are more resistant. The severity of the attack will depend on the heat treatment, generally being greatest for those heat treatments producing low resistance to crack propagation. In many cases the corrosion may be much more severe when stress is applied transverse to the rolling direction.

Generally, it appears that the rate of fatigue crack growth, for materials heat treated to equal strength level, will be higher as the toughness is lower. However, no definite relations have been established in this respect.

If cracks are present in a corrosive environment, the rate of crack propagation under static or fatigue loads may be greatly increased. This effect becomes particularly important when the resistance to unstable crack propagation is low. Under such conditions fatigue cracks would grow rapidly to unstable size under the action of very low stresses.

It does not appear that conventional creep will be a design limitation at temperatures below 600 F with the possible exception of Ti alloys and very heavily cold worked steels. Even for these materials the stresses would have to be quite high.

To Order Paper No. 341D . . .
from which material for this article was drawn, see p. 6.

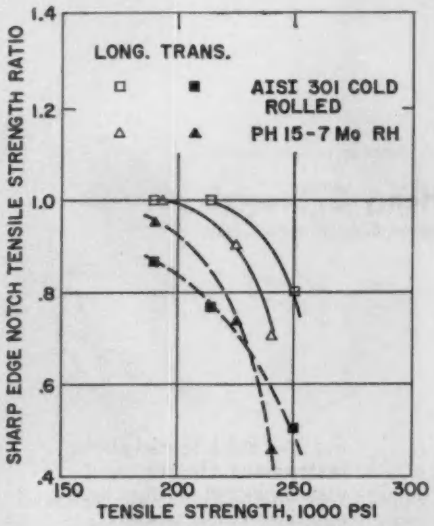


Fig. 4 — Directional effects on toughness for alloys strengthened primarily by cold work and by heat treatment. Greater toughness is produced by cold working, but it depends on direction. Strength is greater in the longitudinal direction.

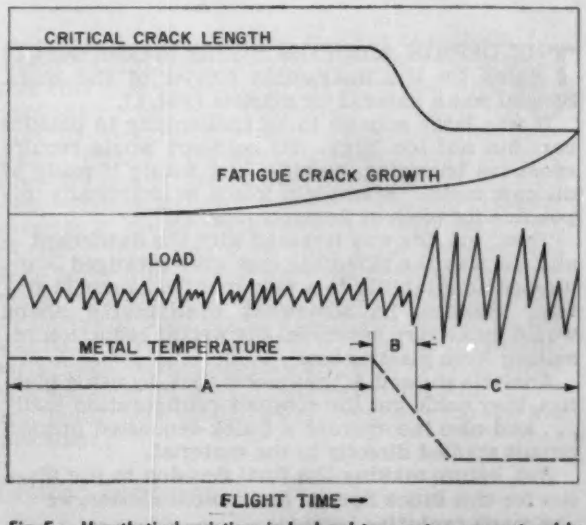


Fig. 5 — Hypothetical variations in load and temperature encountered by supersonic airplane. Crack growth is shown for different periods of flight.

Vibration, heat, and cold tests prove to Buick engineers feasibility of plastics

Based on presentation by

Henry C. Stuerzl
AC Spark Plug Division, General Motors Corp.

Fig. 1 — **Buick Special plastic instrument cluster,** which was subjected to the tests described in this article.

THE DESIGN which GM Styling Section sent to Buick for the instrument cluster of the Buick Special was a natural for plastics (Fig. 1).

It was large enough to be challenging to plastics use; but not too large. Its contours would require excessive trimming, burring, and fitting if made of die cast metal. Stampings would be practically impossible for some of its parts (Fig. 2).

Then, too, the way it mated with the dashboard — and the way the mounting lugs were arranged — indicated adaptability to a very practical support system. Besides, its somewhat overhanging shape would make very beneficial the weight reduction resulting from plastics use.

Analysis showed AC engineers that, by using plastics, they could get the complex configuration easily . . . and also incorporate a Buick-requested printed circuit applied directly to the material.

But, before making the final decision to use plastics for this Buick Special instrument cluster, we

- **made tentative layouts**
- **located parting lines**
- **established contours**
- **worked up general cross-sections of the entire cluster.**

All kinds of materials were considered: modified acrylics, polypropylene, polyester fiberglass premix, the ABS (acrylonitrile-butadiene-styrene) family, acetal resins, filled material, polycarbonates, and others. Each material was investigated — through examination and preliminary tests of sample parts, of manufacturers' specifications, and of AC's own experience and background. Many of the materials were found to meet — or even exceed — many of the requirements. But none actually met ALL requirements. For instance:

- **Acetal resins seemed too costly.**
- **Polypropylene is not readily paintable.**
- **Modified acrylics have low heat resistance and low impact at cold temperatures.**
- **Polyester fiberglass premix has a rather poor surface finish — and may be more**

for an instrument cluster

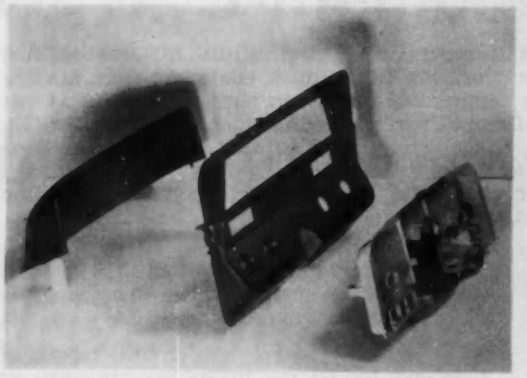


Fig. 2 — **Hood, bezel,** and case of the Buick Special plastic instrument cover.

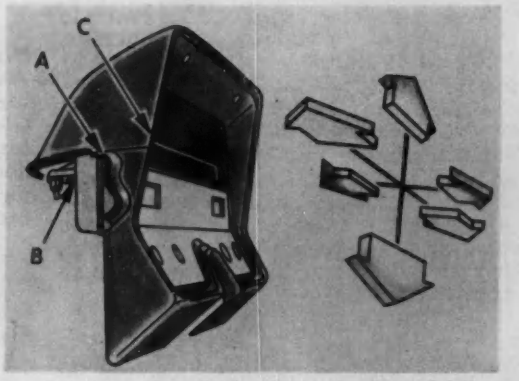


Fig. 3 — **Direction of vibration and points** of failure in vibration test on Buick Special plastic instrument cluster.

costly because of its long cure time in the die.

- Polycarbonates have high materials cost and bring painting problems.

One grade of the ABS family, however, came fairly close to meeting all requirements. Its cost is not excessive. Its impact strength is fairly good. It will accept acrylic lacquers that are commonly used in car interiors . . . and its toughness over a wide range is favorable.

Besides, investigation proved, it can be made opaque without seriously affecting any of its properties; its temperature resistance — though borderline — is in the "safe" range; and it remains fairly rigid throughout the usable temperature range without becoming brittle in the low ranges.

And, finally, this one member of the ABS family had seen instrument cluster service in European cars since 1954; as well as two years in GM trucks.

Once the decision was made for the selected ABS family plastic, the next step was prototype samples. To speed these, aluminum molds were designed and made to permit compression molding of material intended for injection molding methods. Parts made from this type of tooling in the AC model shop were excellent for feel and appearance. But they fell far short of meeting the high temperature requirements. (When a painter in the model shop tried to force-dry one of the painted parts, he put it in an oven. Though the oven was set at a rather conservative 150 F, the part deformed very, very badly.)

Control tests confirmed that none of the model shop parts would pass high temperature requirements. So, Buick decided that production tooling for parts for high temperature tests should be expedited as quickly as possible. . . . In the meantime, parts made by the compression mold method would be acceptable for the car prototype program. From this point, the model shop program ran rather smoothly.

Testing program

Then came the testing program. A number of tests applicable to the production parts had been

plastics for an *instrument cluster*

... continued

established by the time the production tools were ready. These were in three groups:

- Heat and humidity tests in AC laboratories.
- Vibration tests in AC laboratories.
- High temperature tests by Buick engineers at GM's Desert Proving Grounds in Arizona.

Heat and Humidity Tests: Temperatures of 170 F and 95% relative humidity were used to evaluate paint adhesion, forging, shrinkage, and warpage. Three clusters held under these conditions for 8 hr passed all phases of the tests satisfactorily.

Complete clusters were then placed in an elevated temperature test to determine the maximum temperature which the cluster could withstand without deformation. . . . Results showed the ABS material used could reach a temperature of 225 F before deformation was apparent. (This test started at 150 F. The temperature was increase 10 F every hour. This provided a good evaluation of the part up to and beyond the fail point.)

Vibration tests: Proving Grounds data, based on tests using prototype Buicks, had indicated that a damaging resonant frequency could develop at about 39 cps. Accelerometer readings also indicated maximum car vibrations at about a 2¼ g level.

So, in the vibration test, the cluster was vibrated from 10 to 100 cps — and back to 10 cps every 2 min for an 8 hr period in each of three planes (Fig. 3). To insure simulation of the most extreme condition, the cluster was vibrated at 2¼ g input during each phase of the test.

A section of an actual Buick dashboard was substantially mounted to the vibrating equipment. Then the cluster was mounted to this dashboard by its four mounting bosses.

During the first 8 hr run of vibration (in the vertical plane), only a small part of the bezel broke . . . the portion that fits on the leading edge of the panel. Examination showed a stress condition of the bezel at the point of rupture. (See Fig. 3, in which arrow "A" shows where the break occurred.) This break was caused by poor mounting of the test cluster. Subsequent tests caused no more such failures.

The second vibration run was made in the horizontal plane — crosswise of the car. It developed no further damage to the cluster.

The third vibration run — also in the horizontal plane — was lengthwise of the car. During this third run, the left mounting boss started to pull out of the instrument case. Also, a small portion of the hood pulled loose for about 1½ in. along the front edge. Arrows "B" and "C" show these two areas in Fig. 3. Strengthening of the ribs eliminated any further possibilities of these minor failures.

Everyone concerned was happy the cluster withstood 24 hr of this punishing vibration as well as it did, considering that resonant acceleration outputs on the vibrated cluster were over 10½ g, and that the stamped metal dashboard was torn loose from its mounting several times and had to be welded to continue these room temperature tests.

Cold Tests: Next in the vibration test came a check on the durability of these parts at −20 F. . . . To avoid repeating the 8 hr tests, 15 min of vibration in both vertical and horizontal positions was decided to be adequate. This cold test proved that an increase in frequency from 39 cps to 57 cps is needed to get a resonance equal to that experienced at room temperature. . . . The cluster showed no signs of cracking or failure of any kind throughout this cold test.

High Temperature Tests: While AC was making these vibration tests, Buick engineers were making high temperature tests on similar clusters at the GM Desert Proving Grounds in Arizona. . . . For this test, the clusters were painted dull black. Then one of them was placed in a dark blue car, having clear glass, and set so as to receive a maximum radiation from the sun. Results:

- A maximum temperature of 216 F was reached on the surface of the cover molding at 12:30 pm (solar noon).
- At solar noon, the ambient outside temperature was 105 F; the inside car air ambient was 164 F.
- A maximum solar radiation for the day of 1.39 Langleys per min. was recorded at solar noon.
- Although the ambient outside temperature continued to rise until 108 F was reached at 2 pm, the cluster cover molding temperature dropped to 212 F.

The cluster cover showed no signs of deterioration due to this test.

But Buick engineers decided to continue efforts to deform the cluster by a "soak test." In this test, the cluster was placed in a simulated car body, which was set facing the sun for a period of almost a month. Except for an inspection check about twice a week, the car remained completely closed, day and night.

After four weeks — which took the test well into July, there still was no noticeable deformation of the cover molding.

On the basis of these tests and knowledge that the same cover molding had withstood 225 F during AC laboratory tests, Buick agreed to a black cluster . . . and agreed, also, that no problems were to be expected with any of the five other colors.

This paper was presented at a RETECH Conference of the Society of Plastics Engineers in May and at the 1961 SAE Summer Meeting.

NEW 3-member hydrodynamic drive unit

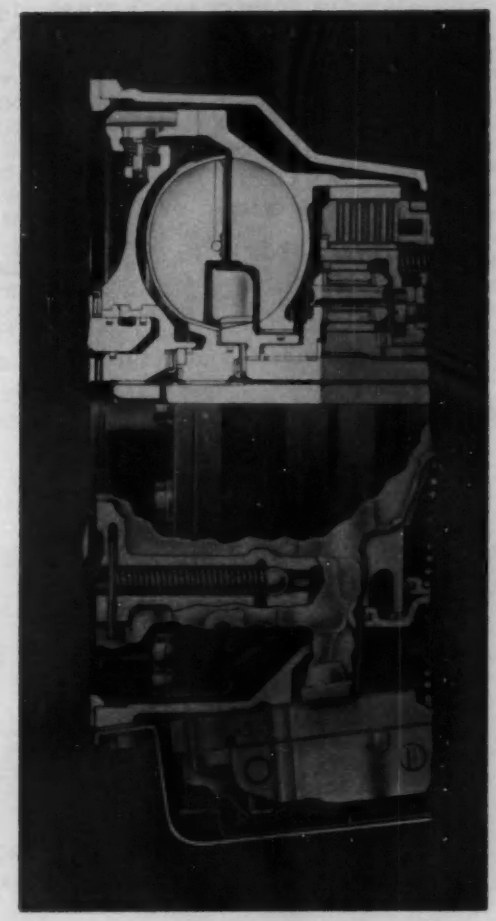


Fig. 1 — **New 3-Member Hydrodynamic Drive Unit.**

has some characteristics of both a fluid coupling and a torque converter . . .

Based on paper by

J. W. Qualman and E. L. Egbert

Detroit Transmission Division, GMC

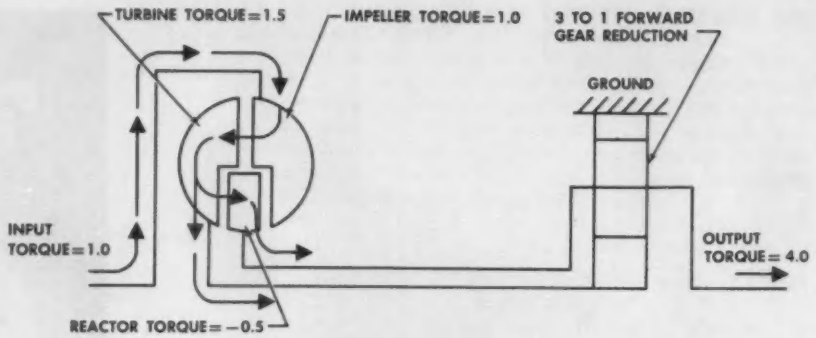
A THREE-MEMBER hydrodynamic drive unit — recently developed at GM's Detroit Transmission Division — has some characteristics of both a fluid coupling and a torque converter. This new device (Fig. 1) supplements the gear ratio in a step-gear transmission with good extension of this torque-multiplying range. Greater overall ratio coverage results with the same number of gear steps . . . or the same overall ratio coverage results with fewer gear steps.

When functioning as a simple drive coupling, the efficiency of the new device is about the same as that of any simple drive coupling. The third member (reactor) is simple and inexpensive, and does not require a one-way clutch. The impeller and turbine members are similar to simple coupling members — and thus are adaptable to the same relatively simple manufacturing and assembly methods.

With the new unit, where the coupling torque is multiplied by a gearset, the overall torque ratio obtained may be increased above that of the gearset alone by adding a third member to the coupling. This member, called a reactor, may be connected directly or indirectly to the output shaft, providing a unit with TWO output members.

If this 3-member unit is used with a forward gear reduction of, say, 3 to 1, the increase in torque ratio due to the reactor will be equal to 3 times the numer-

Figs. 2 and 3 — **Use of 3-member hydrodynamic unit** with forward and reverse gear ratios of 3 to 1. (It is assumed that the reactor torque ratio is negative at stall.)



OUTPUT TORQUE = 3 × TURBINE TORQUE + REACTOR TORQUE
= 3(1.5) + (−0.5) = 4.0

Fig. 2

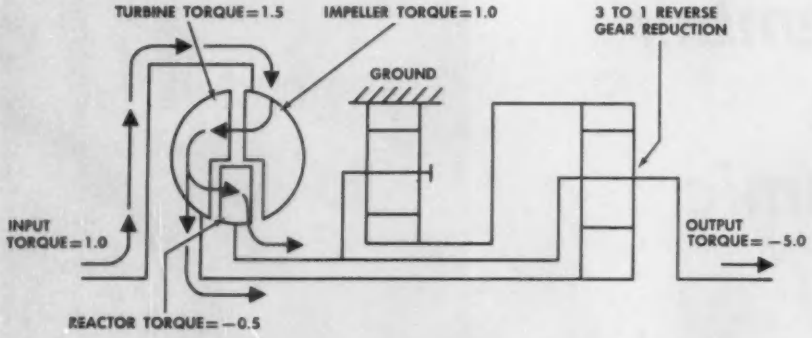


Fig. 3

OUTPUT TORQUE = −3 × TURBINE TORQUE + REACTOR TORQUE
= −3(1.5) + (−0.5) = −5.0

hydrodynamic drive unit

. . . **continued**

ical value of the negative torque on the one output member minus one times this numerical value . . . or a net increase of 2 times this numerical value. If the gearset is 3 to 1 in reverse, these quantities are additives. Then, gain in torque ratio is 4 times the numerical value of the negative torque.

In both of the above cases, the reactor is assumed to be connected directly to the output shaft.

Figs. 2 and 3 illustrate use of a 3-member hydrodynamic unit with forward and reverse gear ratios of 3 to 1 and assuming the reactor torque ratio is negative at stall with a value of 0.5 to 1.

As the output shaft speed increases, the torque characteristics of the output members behave quite similarly to those of the turbine and reactor of a single-stage, single-phase torque converter. That is, the torque ratio of the turbine decreases with increased output speed, while the torque ratio of the reactor increases; i.e., becomes less negative. A point is finally reached where the turbine torque is equal numerically to impeller torque — and the torque of the reactor equals zero. This, in conventional torque converter terminology, is called the coupling point. At this point, torque ratio of the system equals that of the gear train.

At higher speeds, the turbine torque ratio drops below one and the reactor torque ratio becomes positive (as would be the case with a single-stage, single-phase, torque converter). In this range, the overall torque ratio of the system is less than that of the gear train. In actual practice, an upshift occurs very near the coupling point and very little of the range of positive reactor torque is used.

The extension of the torque multiplying range is greater in forward than in reverse, because forward rotation of the reactor causes the torque reaction or negative torque on this member to be maintained to higher output speeds (or turbine speeds).

If the reactor were held stationary to ground (as in a single-phase, single-stage torque converter), the coupling point would occur between those of the forward and reverse rotating reactor. This, of course, would result in higher overall forward torque ratio of the system at stall, since the reaction is not subtracted from the output torque. However, the torque ratio curve would drop faster in relation to output speed and reach the value of the gear train sooner.

Typical Blade Angles for a Three-Member Hydrodynamic Unit: The blade angles are rather mild as compared to common three-member converters, as shown in Fig. 4. This is because only a relatively small ratio of torque multiplication (1.3 to 1.5 as against 2.0–2.5 for common torque converters) is required in a three-speed transmission (current usage). Also, in a typical current application, the unit, when functioning as a two-turbine coupling for direct drive range, operates in the same rotative direction, but with the direction of oil flow reversed. Here, the impeller and turbine members exchange roles. If the blade angles were more severe, the efficiency would be impaired. Since this unit must be as efficient as possible in this range, it is imperative that the blade angles be kept rather mild.

Reactor Blade Angles: Fig. 5 illustrates the effect of reactor blade exit angles on performance characteristics. All other blade angles are common.

Reactor Blade Lengths: Fig. 6 illustrates the effect of reactor blade radial length in an 8.00-in. nominal diameter unit. All blade angles are common.

Limiting radial length for the reactor blades is reached when the blades extend into the outer flow path. This, in effect, would place reactor blades between the impeller and turbine producing a torque on the outer ends opposing the torque on the inner ends, and resulting in a net decrease in reactor torque at stall. In this particular unit, this limiting diameter is approximately 5.60 in. In other words, the reactor stall torque will increase with reactor diameter up to about 5.60 in. and then decrease.

To Order Paper No. 359B . . .
from which material for this article was drawn, see p. 6.

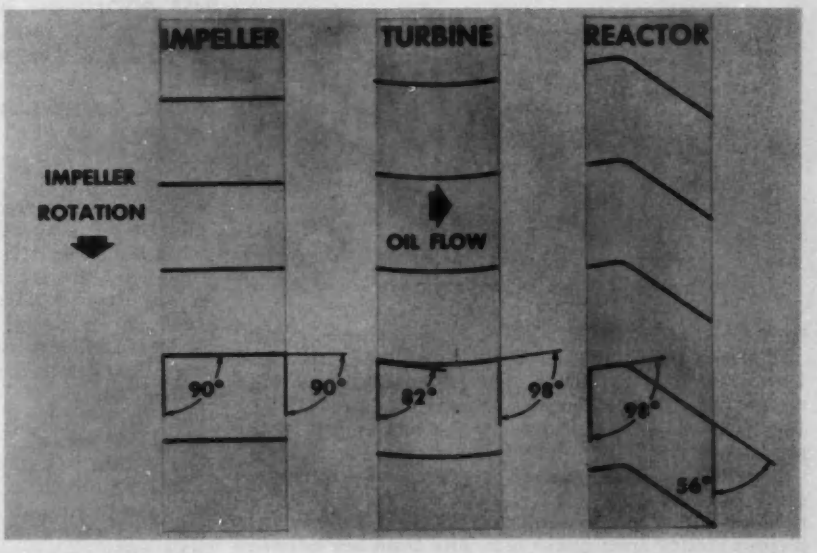


Fig. 4. — **Typical blading** of a 3-member hydrodynamic unit.

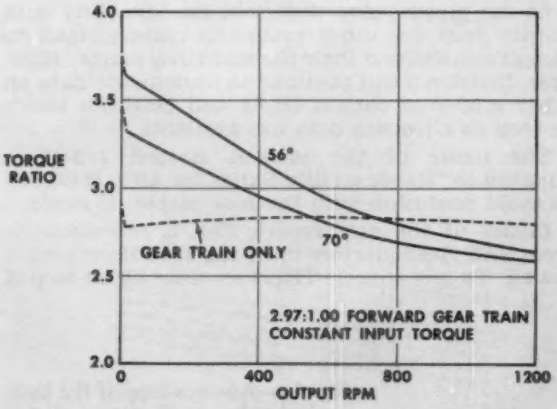


Fig. 5 — **Effect of reactor blade** exit angle in 3-member hydrodynamic unit.

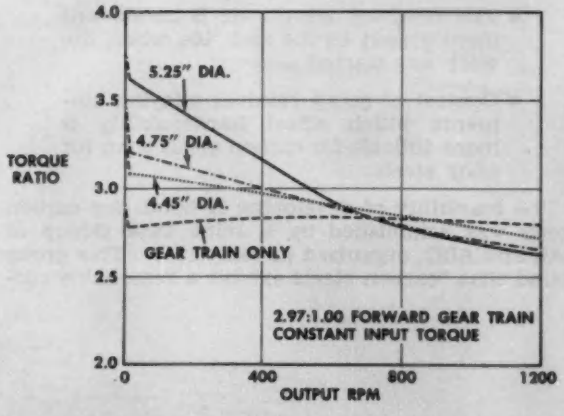


Fig. 6 — **Effect of reactor blade** radial length in 3-member hydrodynamic unit.

H-Bands for Carbon Steels bow in

Just approved are hardenability bands for SAE 1041 and 1045. These bands are the beginning of a carbon steel H-band series paralleling the alloy steel H-bands.

Based on a report by

George Manning

Chairman, Division 8, SAE Iron & Steel Technical Committee

TWO SAE CARBON STEELS now have official hardenability bands. They are SAE 1041 and 1045. These two steels are the forerunners of a whole series of H-bands for carbon steels. The 1962 SAE Handbook will carry the bands, but in the meantime the full report is shown as Fig. 1.

Increased use of carbon steels in the quenched and tempered condition, primarily by the earth-moving industry, has led to the need for uniform hardenability specifications. The time lag between the establishment of H-bands for alloy and carbon steels results primarily from two factors:

- The need for alloy steel H-bands was more urgent in the mid '40s, when the work was started.
- Control of scrap residual alloying elements which affect hardenability is more difficult for carbon steels than for alloy steels.

The feasibility of developing H-bands for carbon steels was established by a Joint Task Group of SAE and AISI, organized in early 1957. This group found that "carbon steels exhibit a reasonable correlation between hardenability calculated from chemical composition and actual hardenability" after an extensive study of cooperative data produced by the steel industry. The most significant steels studied were SAE 1045, 1041, 1046, 1024, and 1038.

To facilitate actual establishment of carbon steel hardenability bands, the Joint Task Group was dissolved in June 1960 and its activities taken over by Division 8 of the SAE Iron and Steel Technical Committee. This new ISTC Division was given the specific assignment of establishing hardenability bands for carbon steels as sufficient data became available. Division 8 concluded at its first meeting that adequate data existed for two grades, SAE 1041 and 1045. In line with terminology used for alloy steels, the bands for the two steels are to be known as SAE grades 1041H and 1045H.

At the present time sufficient hardenability data do not exist for other grades of carbon steels to permit establishing their hardenability bands. However, Division 8 will continue to accumulate data on other grades of carbon steels and establish bands as soon as adequate data are available.

The name of the present H-steel report is changed to "Hardenability Bands for *Alloy* H Steels" to avoid confusion with the new carbon H steels.

Copies of the new report, Fig. 1, are available from SAE Headquarters until the 1962 Handbook is issued. To order, circle TR199 on order blank on p. 6.

Fig. 1 — Advance copy of the hardenability bands for two carbon steels. This report is scheduled to appear in the 1962 SAE Handbook.

HARDENABILITY BANDS FOR CARBON H STEELS—SAE J776

SAE Recommended Practice

Report of Iron and Steel Technical Committee approved June, 1961.

[The SAE Iron and Steel Technical Committee established Division 8 in June 1960, to devise hardenability bands for carbon steels. The American Iron and Steel Institute contributed data on several grades of carbon steels and based on these data, bands for two grades of carbon steel were given the status of Recommended Practice rather than Standard. Division 8 will continue to study these two grades and add other grades of carbon steel to the list as sufficient information becomes available.]

The hardenability bands for carbon steels reported in this SAE Recommended Practice are presented in the same manner used for alloy steels and reported in the SAE Standard, Hardenability Bands for Alloy H Steels. Pertinent sections of this standard are applicable for methods of specifying either hardness limits or distances from the quenched end. The bands are applicable to semifinished products for forging, to hot rolled and cold finished bars, to wire rods, and seamless tubing.

For carbon H steels distances from the quenched end may be specified in half-sixteenths (rather than sixteenths as with alloy steels). Use of sixteenths rather than thirty-seconds is continued in this recommended practice to avoid misunderstanding of units.

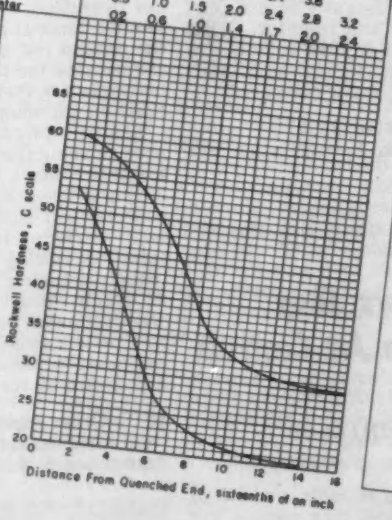
Hardenability tests should be performed in accordance with the section on Hardenability Test for Shallow Hardening Steels in the SAE Recommended Practice, Methods of Determining Hardenability of Steels.

Hardenability Band 1041 H

% C 0.35–0.45 | % Mn 1.25–1.65 | % Si 0.15–0.30

Quench	Location in Round	Diameter of Round With Same As-Quenched Hardness						
Mild Water	Surface	3.8						
	3/4 Radius From Center	1.1	2.0	2.9	3.8	4.8	5.8	6.7
	Center	0.7	1.2	1.6	2.0	2.4	2.8	3.2
Mild Oil	Surface	0.8	1.8	2.5	3.0	3.4	3.8	
	3/4 Radius From Center	0.5	1.0	1.5	2.0	2.4	2.8	3.2
	Center	0.2	0.6	1.0	1.4	1.7	2.0	2.4

Hardness Limits for Specification Purposes		
"J" Distances, sixteenths of an inch	1041 H	
	Max	Min
1	60	53
1.5	59	52
2	59	50
2.5	58	47
3	57	44
3.5	56	41
4	55	38
4.5	53	35
5	52	32
5.5	50	29
6	48	27
6.5	46	26
7	44	25
7.5	41	24
8	39	23
10	33	22
12	32	21
14	31	20
16	30	—



Hardenability Band 1045 H

% C 0.42–0.51 | % Mn 0.50–1.00 | % Si 0.15–0.30

Quench	Location in Round	Diameter of Round With Same As-Quenched Hardness						
Mild Water	Surface	3.8						
	3/4 Radius From Center	1.1	2.0	2.9	3.8	4.8	5.8	6.7
	Center	0.7	1.2	1.6	2.0	2.4	2.8	3.2
Mild Oil	Surface	0.8	1.8	2.5	3.0	3.4	3.8	
	3/4 Radius From Center	0.5	1.0	1.5	2.0	2.4	2.8	3.2
	Center	0.2	0.6	1.0	1.4	1.7	2.0	2.4

Hardness Limits for Specification Purposes		
"J" Distances, sixteenths of an inch	1045 H	
	Max	Min
1	62	55
1.5	61	52
2	59	42
2.5	56	34
3	52	31
3.5	46	29
4	38	28
4.5	34	27
5	33	26
5.5	32	26
6	32	25
6.5	31	25
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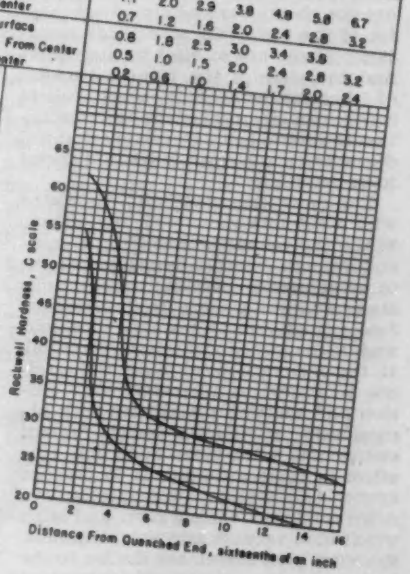
8	30	24
10	29	22
12	28	21
14	27	20
16	26	—



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Radiation in Space Hampers Thermal Control

Based on paper by

R. E. GAUMER
Lockheed Aircraft Corp.

WANTED: a solar reflector white paint which is resistant to the space environment of satellites.

The trouble with presently used white paints is that the absorptance of nearly all of them increases when they are exposed to ultra-violet radiation, like that found in orbit. Since the primary function of external materials and coatings of satellites is thermal control, this increased absorptance has a deteriorating effect on performance. The effect is to cause the equilibrium temperature to rise with the passage of time since the emittance remains largely unchanged.

To ensure that the portion of satellite exteriors used for thermal control perform properly, a knowledge of the environment and its effects on materials is essential. The important characteristics which must be determined are the absorptive and emissive behavior of the materials, as regards radiation. These are so vital because thermal radiation is the principal means of thermal control in space, where convection is non-existent and conduction is minimal. Of course, mechanical degradation is also an important factor to be determined.

The environment usually associated with a satellite starts with the launch. While the vehicle is ascending it must endure high external temperatures due to aerodynamic heating; aerodynamic shear stresses arising from frictional forces; high "g" forces and vibration; and a magnified oxidation potential. In the ensuing orbital phase the satellite is subject to micro-meteorite erosion and sputtering (collision with atmospheric particles); solar radiant energy and ultra-violet radiation (the effect of earth's shadow is to produce cyclic temperature extremes); Van Allen radiation, cosmic rays, and solar wind; high vacuum and weightlessness. Re-entry phenomena are similar to the to the ascent environment, only more severe.

Studies of the effects on materials of these various phenomena show that micro-meteorite erosion is not a great problem. Even for generous flux densities of these particles erosion amounts to only 1% of the exposed surface in one year's orbital lifetime. The same is generally true of sputtering except in the exosphere, where proton sputtering may conceivably be a problem. Van Allen belt radiation also presents difficulties for thermal control materials. Laboratory tests simulating this environment indicate both mechanical and optical degradation of such materials as mylar, lucite, plexiglass, and similar plastics. The same holds true for organic surface coatings.

Tests simulating the effects of ascent heating show no serious effect on bare metal surfaces and inorganic films, but organic film-forming materials suffer severe degradation, as do epoxy and polyurethane vehicles. Adhesive failure at peak temperatures in excess of 300 F in a partial vacuum is also serious. The cause of this is the volatilization of the unstable constituents of the binder leading to excessive bubbling and loss of adhesion. Materials classified as solar reflectors are also seriously impaired by the ascent heating pulse. Only with inorganic vehicles pigmented with highly stable white refractory oxides is satisfactory resistance to the ascent environment achieved.

The solar absorber class of materials, particularly the optically polished metal surfaces, are greatly influenced by oxidation and corrosion. Temperature cycling and extremes have detrimental effects on adhesive-bonded coatings of all types; re-entry thermal shock affects flame or plasma-sprayed refractory oxide coatings used as flat absorbers. Ceramics or porcelain-enamel coatings, used as flat absorbers or solar reflectors are sensitive to the acceleration and vibratory forces generated during exit and re-entry. High vacuum effects are limited to adhesive outgassing and materials with high room temperature vapor pressures.

■ **To Order Paper No. 339C . . .** from which material for this article was drawn, see p. 6.

Signal Sensors Snag Nuclear Ram Jet Controls

Based on paper by

MILTON M. WEINTRAUB
Marquardt Corp.

ACCURATE and reliable sources of temperature and flux signals are needed to further the development of a nuclear ramjet. These signals, used to command the reactor control rod actuating system, must originate from sensors in the meat of the core itself, where temperatures can reach 2600 F at maximum power. Finding suitable sensors is no easy task. Present data indicates that resistance windings mounted on high temperature insulators, such as Al_2O_3 or MgO, are promising temperature sensors for the radioactive environment. Thermocouples also may be used for this purpose, but so far, those suitable for operation at these high temperatures are quite sensitive to radiation, suffering a degradation of emf. Another difficult problem in this connection is sensor installation and signal lead-out from the heart of the core. A reliable method for conducting signal leads transversely through dozens of tubular reactor elements, and fixing thermocouples to a fuel element surface, has not yet been demonstrated. Installation of resistance bulbs appears equally difficult. Blockage of cooling air flow through the reactor is another aspect of sensor installation which must be considered. Otherwise, hot spots can precipitate progressive material failure.

In-flight measurement of reactor flux is also difficult due to the high reactor temperatures. Although it is possible to take advantage of lower temperature areas outside the core by locating the sensors remotely, accuracy would suffer from this practice.

The job of regulating the reactor is crucial since temperature overshoots and oscillations can cause thermal stress. Further complications arise from the exacting performance requirements, one of the more stringent of these being the desirability of controlling the core temperature near its maximum allowable limit. This is a precarious procedure because there is an inherent time lag between a change in flux (power) and the corresponding response in core temperatures. To allow operation near the maximum allowable limit the command signals to the control rod actuating system must compensate for the inherent lag. Lag networks are therefore required to operate on the temperature error signals.

Another problem stems from the need to bring the core up to its operating temperature as quickly as possible during a prelaunch or boost phase, to achieve self-sustaining flight. This fast warmup requirement may be solved by raising the core temperature while the vehicle is still on the ground. Although this would allow rapid warmup since cooling flow is absent, this period would probably have to be extended to reduce the radiation hazard caused by too high a flux power.

■ **To Order Paper No. 338D . . .** from which material for this article was drawn, see p. 6.

Torque Curve of

From a talk by

FRANK W. BALL, JR.
Oldsmobile Division, GMC

(based on report by **Richard E. Young,** Indiana Section field editor)

DESIGN OF THE ALUMINUM ENGINE for Olds F85 car followed an unusual course . . . since it had been decided that the car with this engine should have the same performance as the 1960 Olds 88.

The torque of this 215 cu in. V-8 en-

Rocket Nozzles Don't Get as Hot When Internal Ablation Is Used

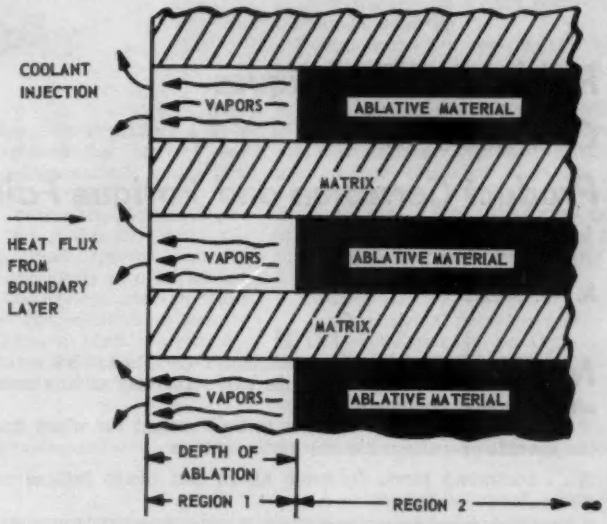


Fig. 1 — Model of internally ablating body. A porous matrix of rather high melting point contains ablative material of lower vaporization temperature.

Based on paper by

FRANKLIN A. VASSALLO

Cornell Aeronautical Laboratory, Inc.

ANALYSIS shows that internal ablation can be used to cool parts of very-high-speed vehicles, such as rockets, and still maintain dimensions.

Ablation cooling makes use of the fact that heat is absorbed by the melting, vaporization, or decomposition of the surface layers of a material. In addition, the resulting gases or vapors tend to thicken the aerodynamic boundary layer, thus reducing the flow of heat to the body. Such a process results in material loss, and the rate of such loss is rather high when shearing and pressure forces are high, such as in rocket nozzles.

Material loss is not desirable for many parts, such as expansion nozzles of rocket engines, where the efficiency of performance depends on the maintenance of throat dimensions. For these situations, dimensional stability can be increased by using an internally ablating body, which means that material removal takes place within the interior of the body rather than at its surface. Such a body is composed of a porous matrix of high melting point, which is initially saturated with a relatively low temperature ablating material. This combines the stability of an efficient heat sink and the heat dissipating ability of both the ablation and the transpiration cooling processes.

Fig. 1 shows how an internally ablating body is constructed. The porous matrix of rather high melting point contains the ablative material of lower vaporization temperature.

The mechanism of internal ablation achieves dimensional stability of the matrix by reducing its rate of temperature rise. This reduction is caused by latent heat absorption, convective or transpiration cooling within the porous matrix, and reduction of surface heating by mass injection into the aerodynamic boundary layer. In addition, the presence of the ablative material increases the sensible heat absorption capacity per unit area of composite.

The process is inherently self-controlling, since the amount of material injection varies directly with the severity of the heating conditions. Thus, it is most useful when weight requirements are strict, such as for rocket nozzle applications.

■ **To Order Paper No. 354B . . .** from which material for this article was drawn, see p. 6.

Olds F85 Engine Determined by Computer

gine, with compression ratio of 8.5 : 1, was determined by computer. The block is a semipermanent mold casting. Heads are of the same material and are vapor blasted for burr removal. Setting up the machining of these parts required considerable work to provide proper chip removal. The light chips tended to stick to the casting, fouling the cutting tools, until proper means were devised for their removal.

Pistons are aluminum and are tin plated to prevent scuffing. Cylinder liners are centrifugally cast iron 0.090 in. thick with square threads cut into the O.D. to hold them in place in the castings as expansion and contraction occur. The cam is cast iron with flame-hardened loads and is supported on five bearings. Rocker arms are ARMA steel, and both these and the cam are phosphate coated. The electronically balanced crank is of cast ARMA steel with five bearings.

The front cover, the water pump housing and the impeller are die cast aluminum and the impeller has a sintered iron hub cast in place. The water-warmed manifolds appreciably reduce warmup time.

Valve springs have a conical shape which gives less surge and pushes resonance frequency quite high. Antifreeze corrosion is not expected to be any more of a problem in this engine than in those of cast iron.

All threads in the aluminum castings are used as cut, the only precaution being to dip bolts or stude in oil before they are installed.

The covered, air-cooled carburetor increases efficiency and eliminates many dirt problems.

The total weight of the engine with accessories is 350 lb.

Production Techniques Can Lead to Product Corrosion and Fatigue Failures

Based on talk by

A. W. MEAD
Grumman Aircraft Engineering Corp.

MANUFACTURING AND ASSEMBLY OPERATIONS can have an important bearing on the service reliability of any product, as all production engineers know.

Here are ten points — factors to be watched for when developing the specific operations for any given design:

1. . . Sustained stress in some alloys can cause fatigue corrosion and subsequent failure.

2. . . Cold forming of materials is the most deleterious method available to cause stress corrosion. Manufacturing techniques involving cold forming should be specified and monitored very carefully.

3. . . Promiscuous use of lubricants containing free graphite can lead to serious corrosion.

4. . . Writing on some materials with a lead pencil can cause corrosion.

5. . . Die marks on extruded surfaces can lead to trouble.

6. . . Weight requirements can sometimes be indirectly the cause of trouble because of the use of inferior materials to cut weight without thorough investigation.

7. . . Promiscuous material substitution is a dangerous practice because Quality Control cannot always detect material differences.

8. . . Swaging some materials, if substituted without proper investigation, is bad practice.

9. . . Aladine and anodize are not necessarily synonymous. One can't necessarily be substituted for the other — although this substitution is not uncommon.

10. . . Quenching is not always 100% effective — and stabilization cannot be detected by Quality Control.

Keep Competitive! Question Machine Value

Based on paper by

GEORGE W. JERNSTEDT
Westinghouse Electric Corp.

NEW, more efficient manufacturing techniques will be needed to survive the severe competition of the 1960's. In many cases, machines will have to be replaced — after only a year or two of operation — by more advanced machines that do the job more efficiently.

Each machine in the plant should be questioned to determine its value and "keep" or "replace" status. Decisions can be made on the basis of answers to the following questions and appropriate cost and expense reduction analysis.

1. Can this operation be combined on other equipment and release this machine?
2. Is there a possibility of securing a design change to eliminate this operation and the need for this facility?
3. Should machine or combination of machines be replaced with improved or special equipment?
4. Can present operation be improved by change in layout or retooling?
5. How many hours are worked per day to meet standard volume?
6. Can we declare machine surplus?

■ **To Order Paper No. 334A . . .** from which material for this article was drawn, see p. 6.

Automatic

Based on paper by

LEO V. BJONG
The Bendix Corp.

THE Air Force AN/GJQ-9 Checkout Sequence Programming Set is a flexible testing device that is directly applicable to various levels of testing of complex systems and to a variety of individual systems without modification. This automatic tape-programmed equipment permits an almost unlimited number of tests points or stimuli control to be handled. (Seven hundred and fifty feet of tape will program 3000 tests, many of which are made in milliseconds). Measurements can be made simultaneously. The equipment checks and doublechecks itself while working.

Weapons System Application

Application of the AN/GJQ-9 to various levels of testing a complex system requires analysis of the specific problem. We can, however, assume a hypothetical missile and consider the possible solution to testing of the complete missile system and, also, the testing of the missile's subsystems.

Fig. 1 depicts four separate test stations for the complete missile and assumes that one missile will be tested at a time. A single Q9 can be installed in this area and one missile adapter used for each two stations. This configuration considers the Q9 in three basic sections:

1. The two-bay operator's console which contains the tape reader, printer, visual display, controls, and basic decoding circuitry.
2. The two-bay measurement and evaluation section, which contains the measurement and comparison circuitry, self-test standards, and the decoding control for selection of test points and stimuli channels.
3. The detachable bay, which contains the hard switching (crossbar for test point and relays for stimuli selection) and the basic power supply.

Assume that program control requirements are beyond the 2000 test points and 300 stimuli control channels of the expanded Q9. We insert a selector bay between the measurement-evaluation section and the detachable bay. This selector bay contains switching devices, a power supply, and some isolation circuitry to simplify connection of pulse information lines from the Q9 to the adapters. The switching devices operate by program codes from the Q9 in a manner similar to operation of the detachable bay. However, we now can select through 10

Checkout System Tests Missiles

channels of the selector bay any one of the 2000 test points and 300 stimuli channels in the detachable bay. This, in effect, increases the control capacity by a multiple of 10; that is, the Q9 with an interposed selector bay can control up to 20,000 test points and 3000 stimuli channels.

Certain advantages occur from the bay concept:

1. The number of control lines for any group of test points or stimuli channel is much less than the actual number of hard switching points involved. Therefore, the number of wires from Q9 to adapter is reduced.
2. The control lines handle sizable, digital-type signals. This type of transmission is less susceptible to problems associated with long cables due to "noise," attenuation, and "cross talk" than are low-level analog and high frequency test leads.
3. The actual wires attached to points of the item under test are minimized in length by the proximity of hard switching to adapters.
4. The selector bay may have the control lines for up to 10 adapters attached and left permanently in place. Cable handling is thereby reduced and the possibility of damage and human errors is reduced. Since the Q9 is directed to the appropriate adapter by tape commands, only the cables to connect the adapter to the item under test must be handled.

Aside from these operational advantages, the multiple use of standardized hardware, such as the test point crossbar switch assemblies and stimuli control relay assemblies, is significant in reduction in cost and logistics considerations.

In Fig. 2, the selector bay is utilized to route control lines from the Q9 to one of a number of adapters. Subsystem testing is conceivably simpler, and the switching can be provided as part of the adapter in standardized assemblies.

A complete missile system is composed of a number of subsystems and modules. The test function for the complete missile is to evaluate the performance of these subsystems separately and in combination. The program sequence and adapter configuration must be designed to isolate malfunction to a subsystem and a section thereof. Similarly, programs and adapter configuration must isolate malfunction in a subsystem to a component or a module therein.

The measurement and isolation function is dependent upon the system under test. It is also dependent upon the extent of analysis needed for a determination. By providing a wide range of programming control capacity and measurement capability, the Q9 assumes a "core" position in a test complex, and variations and peculiarities of test parameters are handled by simplified special purpose adapters. In the study of a particular test problem, the system analysis leads to a separation and sequence procedure for testing. This, in turn, enables design decisions to be made regarding inclusion of special functions into the adapter. In an aircraft or missile system, certain natural division of subsystems occurs which dictates the testing procedures.

Subsystems are generally related and, more often than not, control and respond to other subsystems. The control aspects are generally outputs of a subsystem and the responses result from inputs. The testing function then, either static or dynamic, is to provide precise inputs and evaluate the response. Inputs that may not be provided in the Q9 are intended to be included in the adapter for any test situation.

■ **To Order Paper No. 331D . . .** from which material for this article was drawn, see p. 6.

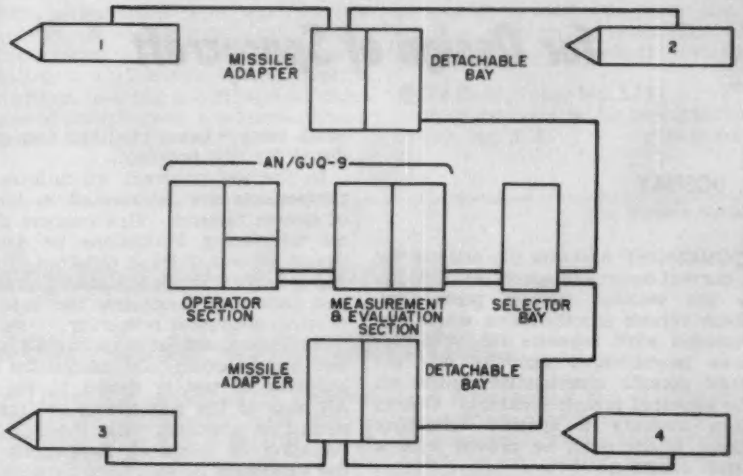


Fig. 1 — Missile system tests arrangement.

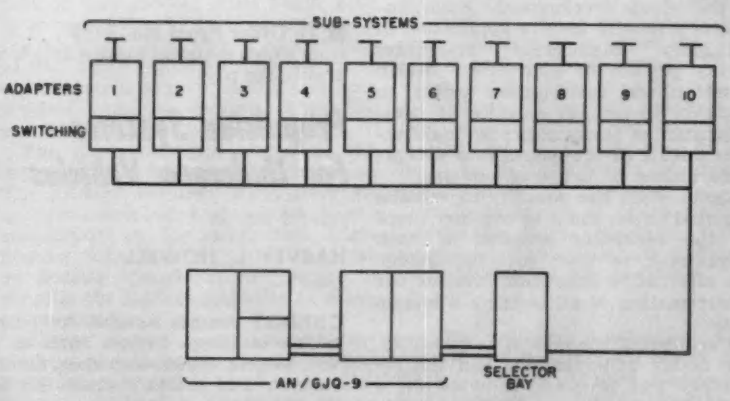
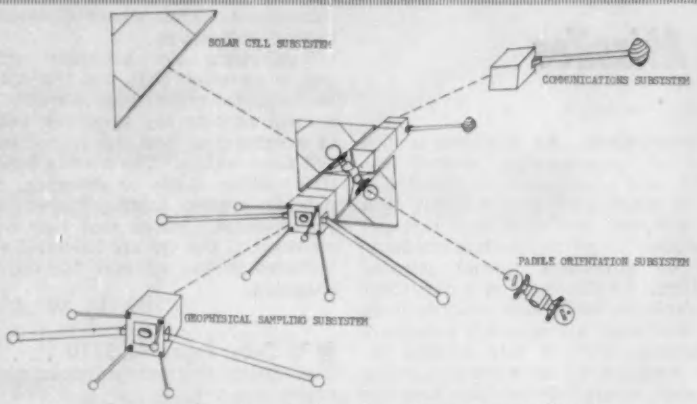


Fig. 2 — Missile sub-system test arrangement.



Spacecraft system broken down for purposes of test.

Mission Success Criteria for Design of Spacecraft

From paper by

I. DOSHAY

Aerojet-General Corp.

FOREMOST AMONG the criteria for current designs of spacecraft vehicles is the mission success probability. Some vehicle specifications which are included with requests for proposals from procurement agencies will include specific quantitative figures on the expected vehicle reliability. Others even indicate a specific reliability figure which must be proved with a given confidence.

To fulfill the reliability requirements of such specifications it is necessary to organize a detailed program encompassing the contribution to each phase of the vehicle development. Such programs generally involve application of reliability engineering procedures which pertain to appropriate design practices and development testing, in addition to general practice of demonstration of performance by qualification testing of prototypes and acceptance testing of delivered systems.

Quite often the quantity of vehicles required is too small to consider proof of the reliability required of each component, or even each subsystem. An alternative approach involves the interpretation of all tests on a system basis.

Considering the system as an entity, the design of equipment and the reliability test program is based on a chosen confidence level. The equipment is therefore designed on the basis of having a reliability goal greater than that required, in order to assure that reliability will be achieved in the small sample being qualified and produced for this program.

In the test program, all failures in components are interpreted in terms of system failures. This requires that all interfacing limitations be determined beforehand and reflected in the test criteria. This approach minimizes test time and maximizes the rate of developing system reliability.

An illustration of a spacecraft system broken down into subsystems for purposes of test is shown in Fig. 1. All tests of the subsystems are interpreted on a system basis through the inclusion of tolerance limitations on the subsystem performance parameters for interfacing to the system. In this manner the system is seen to be effectively tested at remote subsystem locations.

■ **To Order Paper No. 343B . . .** from which material for this article was drawn, see p. 6.

Propulsion Systems For Undersea Vehicles

Based on paper by

HARVEY L. HOWELL

Avien, Inc.

ENERGY sources suitable for propelling undersea devices such as decoys, targets, mines, torpedoes, manned research and military craft fall into one of two categories:

1. The pre-stored system in which the unit is "wound up" prior to launch.

2. The latent energy system in which chemical energy is released through changes in molecular structure.

In the first category are found the mechanical spring and compressed gas which depend upon material stress for energy storage; the flywheel which delivers energy from stored momentum; and a heat reservoir, such as fused salt.

Chemical can be used to generate electricity directly for conversion to mechanical power by means of electrical motors. Energy can also be released through the catalytic action of secondary materials, or by a localized heat source.

The size and weight of a vehicle designed for a specific mission is highly dependent upon the performance of the propulsion system. Use of the rod-crank type of reciprocating engine results in minimum vehicle size for moderate-to-long-range missions.

Exhaust gas pumping is an efficient and practical method for extending the depth capability of the thermal engine to several thousand feet. This system features:

- Performance insensitive to depth.
- Near constant buoyancy of vehicle.
- Elimination of wake and minimizing of noise because there is no overboard exhaust discharge.
- Component design requirements within state-of-the-art.
- Extensive experience available in propellant use.
- Absence of operational tank-to-tank propellant transfer.

Efficient operation of the gas pumping system in the deepest ocean could be provided by advanced structural design of hardware.

■ **To Order Paper No. 349C . . .** from which material for this article was drawn, see p. 6.

How Martin Co. Handles Weapon Projects

Based on paper by

KENNETH P. BOWEN

Martin Co.

WHEN a weapon-system project is inaugurated at the Martin Co., the production department gets a management directive giving the broad point of the intended contract or quotation.

At this same time, a Project Team is organized. This consists of a project manager, program manager, and a project engineer.

A tooling representative develops the tooling policy. Representatives are appointed for the sub-contract Program and "Make-or-Buy" Committee, Procurement, Inspection Test, Planning and Reliability, Manufacturing Test and Checkout Equipment, Contracts, and Estimating.

This group prepares an outline of

the work scope — which is used to develop schedule flow charts for manufacturing sequence and control points. These flow charts, in turn, are used to prepare a cost estimate.

This same team remains with a project until a contract is awarded. Then it follows through on all phases of the proposal from development through production.

■ **To Order Paper No. 342C . . .** from which material for this article was drawn, see p. 6.

Product Reliability Depends on Many Factors

THE CLARITY and good judgement with which a designer sets down product performance and environmental specifications is a major factor in permitting a good product to be turned out at a reasonable cost. Freedom in design and selection of components also has a large effect on product reliability, cost, and ease of manufacture.

Controlling "degradation of reliability" of a product during manufacture is important, too. Certain tasks must be identified and controlled to prevent degradation of failure rates. An estimate between the theoretical reliability of design and the operational reliability required must be made to establish maximum degradation allowance during production.

Field-failure-reporting is another important aid to product reliability. Mathematical models and laboratory tests are needed for a complete reliability system to function efficiently. . . . Secondary benefits from field-failure-reporting include vendor comparison, spares prediction, and quality control effectiveness.

Efforts of production men of every type must be coordinated, also, to insure final product reliability. Production men must be deeply interested in keeping the customer satisfied.

Time-and-failure reporting is another element necessary to reliability control. In aircraft manufacture, such a system aims at producing a time-and-failure history of the various systems and components prior to delivery . . . and at using such information to determine the reliability of various systems, relationships between total flight and ground time, and the effectiveness of design changes or procedures.

(Material for this item was drawn from the report of **Secretary D. F. Smith** of an SAE Panel on "Product Reliability." Chairman of the panel was E. A. Zeiser and members were: H. P. Kean, L. M. Steward, C. W. Russell, A. W. Mead, H. M. McConnell, J. L. Easterday, and A. M. Carey.)

Higher Compression Ratio Engines Stalled

Based on paper by

THOMAS P. DEMUTH

Atlantic Refining Co.

Based on material drawn from an SAE Metropolitan Section

IMPROVEMENTS in the gasoline engine depend largely on increasing compression ratios. The fuels required by these engines will have a high R.O.N., low sensitivity, and additives for surface ignition control. From the technical standpoint there are four stumbling blocks in the path of achieving these higher compression ratios:

- Surface ignition is a major problem. Audible indications of it such as rumble and surface ignition induced knock can be controlled with phosphorous. The optimum concentration appears to be 0.5–0.8 theories.
- Part throttle knock is related to high compression ratio and fuel sensitivity. It can be controlled by using high motor number fuels. A fuel to satisfy a 12/1 engine should have, in addition to a 102 R.O.N. and 0.5 theories of phosphorous, a minimum motor octane number of about 95.
- Spark plug fouling is a very stubborn problem. Phosphorous can help, but a solution seemingly must come from the engine manufacturers, or spark plug and electrical equipment producers, or both. There are ignition systems under development which will fire a spark plug through any type of deposit, but they are too expensive for passenger car use.
- Hot starting problems are not of major importance at this time. There is a faint glimmer of hope for the 15/1 engine. Tests with a range of fuels found them all coming close to meeting full- and part-throttle requirements with this engine, with the exception of alkylate. Both isooctane and alkylate gave evidence of hot starting problems, but these were overcome by putting relatively small amounts of either benzene or toluene in the iso. To blend a full boiling range fuel for this engine, it is necessary to use reasonable amounts of both these materials, hence the hot starting problem in ultra high compression ratio engines may solve itself.

■ **To Order Paper No. S290 . . .** from which material for this article was drawn, see p. 6.

Engineering—Production Seek Good Communications

CLOSE communication is essential between engineering and manufacturing, especially as regards change of product and development of new products.

Through all current discussions of new manufacturing processes and materials runs the cry: "Proper application of this process must begin with its consideration in the design phase of the product." And with it goes a companion cry: "Attention must be given to fabricating techniques and problems involved with this material when the component using it is designed."

The words may not always be the same, but the messages are identical. The product engineer must have an understanding of and accept a responsibility in the production engineering function. . . . And he must be flexible enough in his design to simplify the tooling problems as much as possible.

Mutual respect is an essential ingredient of satisfactory communication between engineering and manufacturing. Without it, there will be no communication.

The product engineer must accept production problems seriously and as real problems. The production engineer must realize the importance of engineering specifications. . . . The designer must specify the accuracy of finish to no greater tolerance than absolutely necessary for proper product functioning. But if a low micro finish is essential, he should say so right at the start of the design, so proper equipment can be bought.

Intelligent use of engineering tolerances can greatly decrease the cost of a part and minimize scrap. The designer should have in mind that the product should perform properly even if some engineering tolerances are not maintained. . . . The car with all parts made to drawing limits has not yet been made!

To achieve all of these necessary interrelationships, constant, reliable, accurate, and mutually-understood communications are necessary.

(This item was drawn from **Secretary Harry Foehringer's** report of an SAE panel on "Better Communications between Product Engineering and Manufacturing." Panel chairman was R. M. Lynas; members were G. R. Fitzgerald, P. H. Ponta, and H. M. Bevans.)

Fuel Anti-icing Additives Forward Flight Safety Step

Based on paper by

W. C. FRENCH
Boeing Airplane Co.
and
E. A. MALICK
Phillips Petroleum Co.

ADVENT of jet fuel anti-icing additives appears to be a basic and far-reaching step forward in flight safety. Its use improves the reliability of jet aircraft as regards safety under ever-present ice-hazard conditions. In addition it promises elimination of components now built into aircraft fuel systems which provide only partial protection against icing, while being sources of mechanical difficulty at the same time.

These conclusions grow logically from study of results of several years' intensive laboratory and flight testing by the United States Air Force, and by Boeing-Wichita under Air Force sponsorship.

Throughout the flight test program, there was not a single engine malfunction due to icing on heaterless engines using fuel containing Phillips 55MB additive. On every flight but one, however, the heaterless nonadditive jet engines flamed out or malfunctioned due to icing when using cold fuel (−30F) with water content of 100 ppm and 800 ppm.

Fuel filters on nonadditive engines were 50 to 100% covered with paste ice or slush ice. Filters on the additive engines ranged from no ice to a few small crystals. The latter occurred when the original fuel additive content was much lower than 0.1.

Flights using fuel with water content of 100 ppm at approximately 0 F — and flights using fuel as received from the tank farm — resulted in on flameouts or malfunctions on heaterless engines using either additive or nonadditive fuel. However, in the flights with 100 ppm water, filters on nonadditive, heaterless engines were covered from 0 to 100% with paste ice or slush ice, while filters on additive engines contained no ice.

During one long-duration test flight, fuel temperature in the test engines dropped below +20 F about 10 hr after takeoff, and thereafter remained below freezing. Under these conditions, the nonadditive, heaterless engine was slow to respond to the throttle during the refueling program. Also it showed slightly erratic operation later . . . and flamed out while in the landing pattern. The additive, heaterless engine gave no difficulty.

These results indicate that, with proper use of fuel heaters, protecting against icing downstream of the heaters is obtained. Additive use provided icing protection without the use of heaters, and, in addition, gave protection in the system upstream of the heaters. At the same time it allowed water drainage from the tank sumps at temperatures below 0 F.

■ **To Order Paper No. 356B . . .**
from which material for this article was drawn, see p. 6.

Gun Drills Cut Super Alloys

Based on paper by

D. A. STEWART
General Electric Co.

GUN DRILLING has advanced from a single-purpose art to a high speed production operation. It has found increasing use on such conventional materials as steel, cast iron, and aluminum.

Tests to determine if gun drilling was applicable to the nickel based materials that are commonly classed as super alloys show that high accuracy holes with excellent finish can be obtained when correct cutting conditions are used.

Hole drilling is performed regularly in many parts. Drilling isn't a critical operation when the length-to-diameter ratio is small and the material is readily machinable. As the depth of hole increases without an increase in drill size, the standard twist drill become less effective and special tools are required. For larger diameter, through holes, a trepanning or core producing drill will remove large volumes of material with the least amount of chips produced. For blind holes or holes of less than 1½ in. diameter, a gun drill is adaptable.

Gun drill construction consists of a hollow shaft rolled from tubular steel to form a flute. A cutting tip of carbide or high speed steel is brazed to the shaft and ground concentric with a suitable holding adaptor. The single cutting edge is guided by integral wear pads as the cutting takes place. Drills are built in a variety of lengths and diameters, but the design is basically straight to within 0.002 in. per ft have uniform. Holes several feet in length been drilled in conventional materials using this method.

Super alloys are difficult to drill under ideal conditions, and when hole depths are greater than three diameters, this difficulty increases. Gun drilling as a means of producing holes of less than ¼ in. diameter to depths up to 6 in. was investigated by GE.

After giving proper consideration to such factors as lubricants, feed rates, cutting speeds, geometry of the gear drill, and grade of carbide tool — and using an inverted drilling procedure — gun drilled holes 6 in. deep were drilled in super alloys U-500, U-700, and DCM to diameters as small as 0.093 in. Holes of 12 in. length with 0.125 in. diameter were drilled but presented problems. Finishes averaging 15 microin. can be consistently obtained. Hole sizes can be obtained within 0.0005 in. of the carbide tip size. Carbide tips taper approximately 0.0005 in. over their usable length for clearance purposes. This means it is possible to maintain a hole tolerance of 0.001 in. over the usable tip length.

■ **To Order Paper No. 340K . . .**
from which material for this article was drawn, see p. 6.

CERAMICS Potentials for Radiative-type Heat Shields

Based on paper by

R. M. DAVIS
The Martin Co.

CERAMICS have good possibilities as materials for the radiative-type heat shields suitable for the lift-type re-entry systems destined for future re-entry-from-space vehicles. (Current re-entry vehicles use the ballistic re-entry technique, for which satisfactory heat shields of the heat-sink or ablative type have been developed by national ICBM programs.)

The long periods of heat exposure during lifting re-entry make the radiative-type heat shields applicable. And the high surface temperature which ceramics can sustain make them a particularly attractive material for such shields, recent investigations by the Martin Co. indicate.

Ceramic foam shields can be built, Martin engineers conclude from investigation of use of available ceramic materials, particularly SiC and SiO_2 ceramic foams. Tests of these materials fabricated into radiative heat-shield material were successful. These ceramic foam shields utilize continuous and semi-continuous type supports to overcome the brittle low strength character of ceramic foams.

Martin is going forward currently with further investigations involving use of higher-temperature ceramic materials, particularly Al_2O_3 and ZrO_2 ceramic foams. So far, there appears to be need for improved quality control of the ceramic foams to make them useful as heat-shield materials.

■ **To Order Paper No. 354C . . .**
from which material for this article was drawn, see p. 6.

SAE NEWS

- Sections Board Brings New "Assists" to Section Officers 104
- Letters from Readers 104
- Better Member Service per $ Is Aim of Section "Guide" 105
- My European Impressions — by PRESIDENT A. A. KUCHER .. 106
- National Meetings Schedule 111
- Technical Moves Forecast at 1961 SAE SUMMER MEETING .. 112
- Rambling through the Sections 122
- SAE Members 124
- New Members Qualified 140
- Applications Received 143

Sections Board Brings New "Assists" to Section Officers

FRESH EVIDENCE of continued progress in the Sections Board program came to light in St. Louis, both at the Sections Board meeting where Sections Board Chairman Paul F. Allmendinger presided and in the Board's later report to the SAE Board of Directors.

Recent advances include "How Should We Spend Our Money?" — a new guidance pamphlet* prepared by the Sections Board Finance Committee under the chairmanship of George J. Liddell; "Section Members Deserve First-Rate Meetings," soon to be distributed as "guideposts" in planning local meetings; and establishment of a Publications Advisory Committee.

PAUL F. ALLMENDINGER (left), 1961 Sections Board Chairman, presiding at the June meeting of the Board in St. Louis. With him is Hollister Moore, manager, Membership and Sections Division, SAE headquarters staff.

In addition to being liaison with the national Publication Committee, the Board's new Publications Advisory Committee will:

- Devise and implement means by which individual Sections, Groups, and Student Branches may have assistance in improving the technical content of papers for their meetings through: identification of local program interests; determination of sources for papers to meet these interests, and help to insure proper preparation and presentation of these papers.

- Establish a review committee whose function shall be to read and evaluate technical papers presented before Sections, Groups, and Student Branches, and to determine their suitability for publication as SAE Preprints.

Progress was reported on an extensive revision of Sections Procedure by the Sections Board Administrative Committee . . . and the Student Activity Committee has re-emphasized its program to cooperate with local Sections in building student activity.

The Board commented on the enthusiastic response of the Sections to the activities of the Area Coordinators, and to the Regional Section Officers Conferences . . . and reported plans for two more Regional Conferences; in August during the National West Coast Meeting in Portland, Ore., and in September during the National Heavy Duty Meeting in Milwaukee — with Area Coordinators participating.

* See p. 105 for detailed story.

Engine Subcommittee Holds Workshop Session On Piston Rings and Cylinder Bores

THE Engine Subcommittee of the SAE Passenger Car Activity experimented with a novel workshop-type session on engines at a recent SAE National Meeting. Purpose of the new format was to provide an atmosphere for free transfer of technical information through active participation by SAE members.

As each member entered the room, he was handed a list of thirty questions. These were divided into three groups of ten each. The first group dealt primarily with the wear of piston rings and cylinder bores. The second group covered piston rings and the third group cylinder bores.

The members then had the opportunity to discuss any of these questions which interested them. Although all the questions were not answered completely, the discussion at least illuminated some of the dark areas surrounding them. On many of the questions a spontaneous and wide-ranging discussion developed.

The workshop session was recorded on tape. The tape was then rerun for members of the Engine Subcommittee. who summarized the points brought out in the discussion. This summary appears on p. 33.

The session was planned by the SAE Passenger Car Activity Subcommittee on Engines whose members are: John S. Wintringham of Ethyl, chairman; A. E. Cleveland of Ford; William S. James of William S. James and Associates; R. J. Templin of Cadillac; and H. L. Welch of Chrysler.

SAE LETTERS FROM READERS

From:

Gerald D. Nepon
2833 Greenleaf St.
Allentown, Pa.

Dear Editor:

I give up! ! ! Since the nature of my work had changed to some extent, and time did not allow for full participation in any of the activities which interested me, I dropped my SAE membership. Now I find I miss the Journal and the interesting ideas which the SAE brings to the attention of the members. I would like very much to reinstate my membership.

Better Member Service per $ Is Aim of Section "Guide"

"ALL FUNDS, regardless of source, belong to SAE members and should be used for their benefit," Sections are reminded in a new report, "How Should We Spend Our Money?" just released by the Sections Board. Prepared for the Board's Finance Committee, whose Chairman is George J. Liddell, the report urges the importance of keeping this basic thought in mind when the Section has some extra money and wants to put it to good use. The report brings out that:

There are at least three ways, according to the SAE Constitution, in which a Governing Board can spend members' money for members' benefit:

- By spending to collect and disseminate pertinent technical information.
- By spending to increase the value of SAE membership to members.
- By spending for other member services in the Society's technical areas.

Meetings afford Sections their principal opportunity to spend for collecting and disseminating pertinent technical information. A Section may well spend up to $1.75 per member per year for preparation and mailing of meeting notices, Section Board studies indicate, without handicapping other member services. This amount, experience shows, can provide attractive, informative, and effective notices of meetings. . . . Then meeting expenses, other than announcements should be minor.

Dinners, social periods, and refreshments before or after Section meetings normally should be self-supporting — if Section funds are to be properly allocated. . . . And the good photographs, which SAE Journal appreciates, need not require a professional photographer.

Committee activities, the report continues, should spend much more time and effort than money. Whether any or all Governing Board and/or committee meals should be charged to the Section depends on the state of the local treasury and the decision of the Governing Board. Here again it is important to be conscious of the fact that "All funds belong to SAE Section members. . . ." The Governing Board will want to allocate funds to benefit the entire Section; not to a few working members, however dedicated their service.

Membership promotion, too, requires much more in the way of member time and effort than of money.

General Expenses

The fact that an item is listed in the SAE Section Budget Form does not mean that every Section is expected to spend money on every item. Very large Sections operate on a scale which requires more expenditures in terms of total dollars, but their operating cost per member per year is still under $4.

Paid secretarial help is not justified for a small Section or Group . . . but a small honorarium to a Board member's secretary or assistant may not be out of order.

Auditing of Section accounts in a small Section doesn't require professional help, either. Auditing may be done by the Governing Board or by a small appointed committee.

Special Expenses

As indicated on the Section Budget Form, special expenses must be approved by the Section Board BEFORE either a committment or an expenditure is made.

In conclusion the report says: "The Sections Board and its Finance Committee want to see the Society's money spent in the best interests of the SAE, the Sections, and all members."

SAE Publication Changes

DAVID L. STAIGER (left) has been named manager and editor, Publication Division, of the SAE headquarters staff, SAE Secretary and General Manager Joseph Gilbert has announced. Staiger has been associate manager of the Division, of which Norman G. Shidle has been manager.

Staiger was a member of the SAE Technical Committee Division staff for several years prior to joining the Publication Division as assistant manager in 1957. He has had full responsibility for organization and administration of the new staff and procedures for the Division's General Publications Department, recently organized to handle the Society's expanded facilities for publication of unabridged technical material. Prior to 1950, Staiger taught aerodynamics for five years at Rensselaer Polytechnic Institute, from which he graduated with B.S. and M.S. degrees.

NORMAN G. SHIDLE (right) continues as editor and manager of SAE Journal and will devote full time to SAE Journal duties beginning August 1, when Staiger assumes his responsibilities as Publication Division manager and editor.

SAE Directors Visit Sections, Groups, and Branches

ELEVEN of 13 members of the SAE Board of Directors who offered to represent President A. A. Kucher at Section, Group, and Student Branch meetings have been scheduled for appearances before these local Society units. All 13 Board members have received acknowledgments of interest by SAE Sections, Groups, and Branches, although definite dates have not yet been completed for the visits of two Directors.

Both Sections and Student Branches have expressed equal interest in inviting Board members to be featured speakers for their meetings, continuing a trend evident since this program first came into being two years ago. A total of 26 Sections and Groups, and 21 Student Branches are represented.

Prior to the SAE Summer Meeting, L. C. Kibbee, J. H. Dunn, R. H. Isbrandt, Paul Allmendinger, and R. R. Robinson had represented President Kucher in the East, Midwest, and West.

Definite commitments have been made for the Fall for H. L. Hibbard and M. J. Kittler, with tentative arrangements being set up for five other Board members.

WHILE IN PARIS, DR. AND MRS. KUCHER were honored at a formal dinner by SIA, the French automotive engineering society. Dr. Kucher is shown here expressing his appreciation to SIA President Paul Huvelin and the others present for their cordial hospitality.

ONE OF THE MOST INFORMATIVE SESSIONS IN PARIS was an interchange between President Kucher and the SIA officers, past presidents, and key committee chairmen. He is shown here, third from left, with: P. Dumanois, Honorary President, SIA Fernand Picard, Past President, SIA, and Past President, FISITA; Paul Huvelin, President, SIA; and John H. Pitchford, current President of FISITA

AT A MEETING OF THE AUTOMOBILE DIVISION of The Institution of Mechanical Engineers in London, Dr. Kucher presented a paper entitled "Automotive Engineering: Reflections and Projections." At Dr. Kucher's right are William M. Heynes, Chairman of the IME Automobile Division, who presided, and Reginald Main, Assistant Secretary of IME. At Dr. Kucher's left is Joseph Gilbert, SAE Secretary and General Manager.

Society Meetings

IN THIS ARTICLE, President A. A. Kucher presents his report to the membership on his three-week trip last May through England, France, Germany, Switzerland, and Italy. The trip consisted of a series of official visits as SAE President and was productive of a furthering of mutual understanding of European automotive engineering societies. SAE President Kucher was accompanied by SAE Secretary and General Manager Joseph Gilbert.

Of the formal European society meetings in which he participated, DR. KUCHER SAYS:

Without exception, the reception I received at the formal society meetings I addressed was warm, cordial, and friendly. I spoke before the following groups:

- The Automotive Division of The Institution of Mechanical Engineers in London
- The SIA (French Society of Automotive Engineers in Paris)
- The Automotive Division of Verein Deutscher Ingenieure in Cologne
- The ATA (Italian Society of Automotive Engineers in Turin)

Especially interesting to me was the vigorous discussion that followed each of the presentations. As a generality, the European engineers attending society meetings are much less reluctant than American engineers to get up and ask a question of the speaker. As a matter of fact, they very much enjoy trying to put the speaker on the spot by asking leading questions. This makes for vigorous interchange and is productive of good sound engineering discussion. This is one quality common to European society meetings which we could use more of in SAE.

Several interesting events in my society contacts may be worth mentioning. For example, most constructive to me was a meeting set up by the SIA with all of its officers and key members in attendance, during which I was given a complete resume of the activities and objectives of the society. What's more, the participants were kind enough to deliver their presentations in English. The men questioned me concerning SAE operations and showed special interest in the standards work of the Society and the relations to organizations such as the American Standards Association, American Society for Testing Materials, the International Standards Organization, and the Automobile Manufacturers Association.

In Cologne, the VDI meeting was arranged with simultaneous translation available. I am afraid I gave the interpreter a hard time until I realized that I had to pause periodically so that he would have time to translate into German the remarks which I made.

A cocktail reception following my presentation to ATA in Turin permitted me to meet with a number of SAE members who were invited to attend the meeting. Some of them came from as far away as Milan, a distance of some 100 miles.

In England, the tea preceding the meeting and the dinner following it

Continued on page 110

A TOUCH OF THE PAST is blended with a look into the future during SAE President's visit at Renault's Engineering and Research Center at Roueil. Shown in one of the earliest Renault motor cars are, left to right, SAE President Kucher, SAE General Manager Joseph Gilbert, Fernand Picard, Chief Engineer of Renault, and Gaetan de Castelet, M. Picard's assistant.

My European Impressions

By

SAE President A. A. Kucher

EUROPEAN ECONOMY Is on the UPSWING

THREE weeks of intensive visits through Europe last May as President of the Society left me with sharp, fresh impressions of automotive engineering and manufacturing technology abroad as well as a new understanding of the problems and progress of the countries I visited. If I had to sum up my report in just one sentence, I would say that: "Europe is on the march technically in the automotive field."

My report grows out of meetings of four engineering societies which I addressed, a get-together with the officers of a fifth society, visits at some ten industrial installations, plus discussions with scores of engineers, automotive executives and SAE members.

Although it is often dangerous to generalize from isolated experiences, I would like to pass on to you my impressions from the observations I made during my visits in England, France, West Germany, Switzerland and Italy.

To understand and appreciate fully the engineering and manufacturing activities of the automotive industries in Europe, one should be aware of the conditions abroad which are obviously different from those in our country. To begin with, much of Europe is enjoying an unprecedented economic boom, which is hard for us to understand these days. In Germany and Switzerland, for example, the biggest shortage in industry is labor. Automotive factories in both countries em-

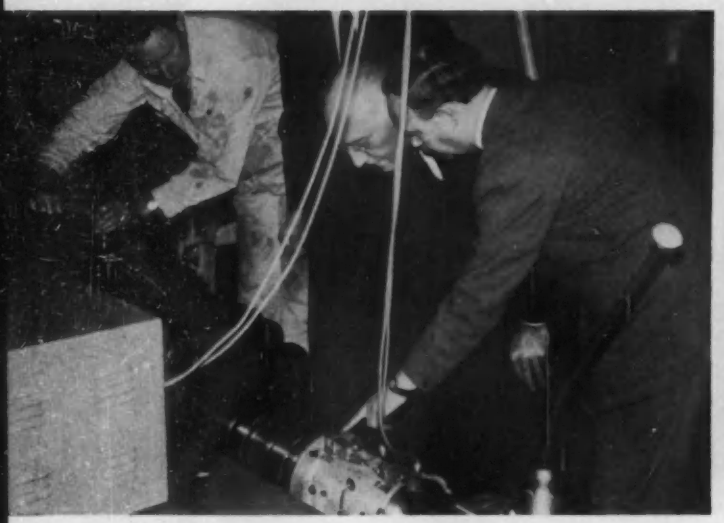
My European Impressions

. . . continued

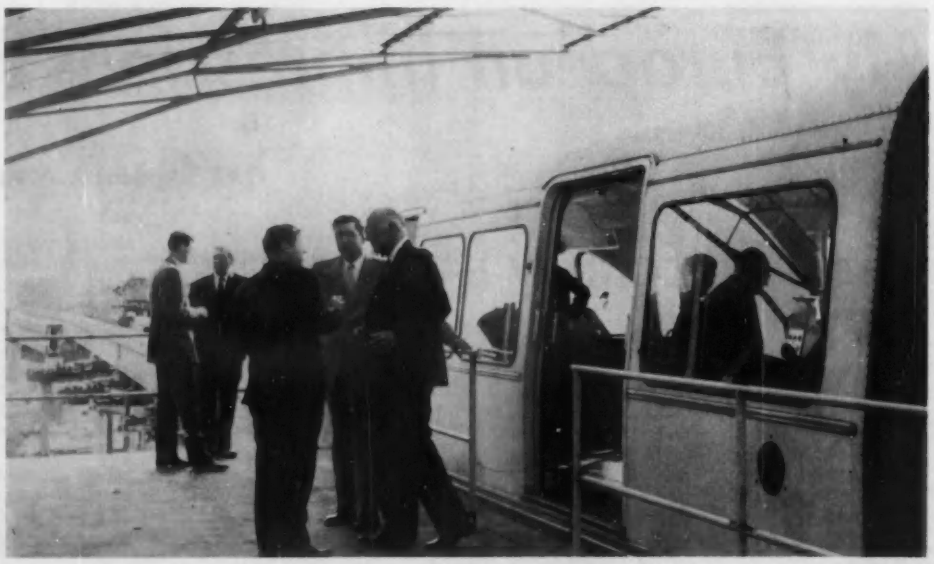
ploy men from countries such as Spain, Portugal, Southern Italy and Greece. Industrial organizations are actively recruiting labor in these countries. There is almost as great a shortage of people in all categories, including the white-collar and engineering groups in both Germany and Switzerland.

The population of the combined European market is 210 million people, so that the potential market for automobiles is larger than the U. S. market. The bicycle and motorbike are still important modes of transportation. The expansive parking space for these two-wheelers at both the Renault and Fiat plants gave us evidence of that. There are still more than four million motorbikes in France. However, a marked decline in the sale of two- and three-wheel vehicles was indicated.

There is no question that the automobile is growing in importance and that every family strives to buy one. Many we talked with in Europe are greatly concerned over the lack of adequate highways and roads. None of the countries abroad have the tremendous network of parkways, turnpikes, expressways and freeways that we have



WHILE AT FORD'S ENGINEERING RESEARCH CENTER in Birmingham, Dr. Kucher, second from right, examined an electrical rig as well as other electrical equipment. He also inspected disassembled engines which had been dynamometer tested, as shown at right.



BECAUSE OF HIS INTEREST IN MASS TRANSPORATION INNOVATIONS, Dr. Kucher was shown the Alweg monorail car and test rail installation at Cologne. This particular installation was built to help in development of the system and consists of one car and approximately a mile of track, including switches, as indicated at far left.

in our cities and across the country. Already the pinch is being felt because the roads in Europe are not equipped to handle the explosion in automobile population.

An interesting aside is that the rapid growth in the number of new drivers plus the lack of maximum speed limits on the open roads combine to create serious safety problems.

The small car is definitely right for the European market. That's so for three obvious reasons:

1. The great desire of the European populace to buy cars, coupled with limited disposable income, demands that the car be as low in price as possible.

2. The relatively high cost of gasoline makes fuel economy a significant criterion for the European car buyer.

3. Major European cities are many hundreds of years old, with many of their streets laid out for horses and wagons. A full-sized American car would find it difficult, and in some cases almost impossible, to negotiate some of the European streets.

With price a factor, driving conveniences such as automatic transmissions become of very secondary significance to the mass European market. That's particularly the case when an automatic transmission in Europe may run as high as 10 per cent of the price of the car — even with more luxurious

continued on next page

DURING HIS TRIP THROUGH ENGLAND, Dr. Kucher inspected the facilities of the Motor Industry Research Association, an industry-government test and development facility in the midlands. At left, Mr. E. G. Giles, Assistant Director of MIRA, is showing Dr. Kucher, center, and Mr. Michael Ronayne, Chief Engineer of Ford in England, parts which had their life extended by a cold-working process developed at MIRA. At right, Mr. Giles is describing a special piece of test equipment and a project under way at MIRA laboratories.

DURING HIS VISIT at Ford's Dagenham plant, Dr. Kucher stopped at the Body Design Section.

My European Impressions

. . . continued

vehicles in the $3,000 and over category.

Therefore, we should expect to see much less emphasis in Europe (at least for some time to come) on features which have become commonplace in our cars . . . such as power steering, automatic transmission, power-operated windows and seats, and other luxury appointments. The mass European market at present can afford only minimum transportation vehicles.

Industrial Renaissance

Considering the fact that a devastating war racked all of Europe less than two decades ago, the recovery of industry has been astonishing. There is no question that the automotive plants we visited are equally as modern, as technically advanced, as any of the manufacturing facilities in our country. Among the installations we visited were Ford in England and Germany; the test track, wind tunnel and research labs of MIRA (Motor Industry Research Association) near Coventry, England; the Opel Works in Germany; Renault's research laboratories in France; and Fiat's research laboratory and plants in Turin, Italy.

In each of these plants, the most modern automation equipment was in full use. Transfer machines for machining engine blocks are fairly common. In fact, Renault builds its own machine tools and also sells machine tools to manufacturers in France and other countries.

One of the most unique operations we were privileged to see was a newly completed line for automatic assembly of steering mechanisms at the Renault factory. Although the installation is fairly new and the economics have not been completely worked out, there are indications that the automatic assembly line requires about one-third the labor of the former manual assembly operations.

In Germany and Italy, considerable expansion of capacity is under way. New plants and extension of existing ones for automobile manufacture are very much in evidence. For example, Fiat officials told us that currently they have capacity to build 2,500 cars a day, and they are now expanding to a capacity of 3,500 cars a day.

It was interesting to note that the labor rates in Europe are roughly one-quarter to one-third of what they are in the United States. The same ratio holds for salaries of engineers. Automation and automaticity in manufacturing operations are very much the order of the day. Terrific competition and the desire to make the automobile available to as many as possible by keeping its price down comprise the incentives spurring all manufacturers.

Engineering Observations

At the present time, few automobile manufacturers are blessed with the ex-

Society Meetings

continued from page 106

gave me a wonderful opportunity to visit with SAE members as well as IME members and officers.

As an interesting aside, we learned that The Royal Aeronautical Society is sponsoring a contest with a prize of 3,000 pounds (equivalent to $8,400) for the first individual to produce an aircraft completely powered by man. Requirements are that the vehicle operate for one mile, describe a figure eight, at a minimum distance of 10 feet off the ground. From what we learned, there is a great deal of interest in this contest and quite a few people are working on flight vehicle designs to accomplish this feat.

The European societies seem to follow a common format, somewhat different from ours, for their evening meetings. These events start in the late afternoon and run to about 7 p.m. This permits those who attend the opportunity to leave early and get home for dinner if they so wish. The method is not without merit.

A common reaction received from all is the great respect in which SAE is held by the European societies for its work. I was also told how enthusiastic many of the Europeans were over the International Congress at Cobo Hall in Detroit last January.

I am sure that Mrs. Kucher, who accompanied me, and I will long remember the courtesies and cordial reception given to us at all of our ports of call.

European Engineers and Executives Contacted by President Kucher

"At the risk of omitting some names," President Kucher says, "I would like to say thanks to the following engineers and executives with whom I visited during my trip abroad. They were all extremely helpful in making my visit both constructive and pleasurable."

ENGLAND:

W. M. Heynes, *Chairman, Automobile Division, The Institution of Mechanical Engineers (IME)*; B. G. Robbins, *Past Secretary, IME*; Kenneth Platt, *Secretary, IME*; Reginald Main, *Assistant Secretary, IME*; J. H. Pitchford, *President, Federation Internationale des Societes d'Ingenieurs des Techniques de l'Automobile (FISITA)*; Sir Patrick Hennessy, *Managing Director, Ford Motor Company Ltd.*; Michael Ronayne, *Chief Engineer, Ford*; J. G. Giles, *Assistant Director, Motor Industry Research Association (MIRA)*; Hugh Harvey, *member of SAE International Information Committee*; L. H. Dawtrey, *Past Chairman, Automobile Division, IME*; Dr. A. M. Ballantyne, *Secretary, The Royal Aeronautical Society (RAS)*; and Dr. E. S. Moult, *Past President, RAS.*

FRANCE:

Paul Huvelin, *President, Societe des Ingenieurs de l'Automobile (SIA)*; Jean Martin, *Administrative Delegate, SIA*; Paul Pinier, *Secretary General, SIA*; Fernand Picard, *Past President, FISITA, and Chief Engineer, Regie Nationale des Usines Renault*; Robert Geffroy, *Past Secretary General, FISITA*; Rene Dreyfus, *President, Renault*; Gaetan de Castelet, *Assistant to Chief Engineer, Renault*; and P. E. Bezier, *Renault.*

GERMANY:

J. S. Andrews, *General Manager, Ford-Werke Aktiengesellschaft*; J. A. Gutzeit, *Director Product Engineering, Ford*; Prof. Dr. Ing. Paul Koessler, *President, Verein Deutscher Ingenieure Fachgruppe Fahrzeugtechnik* (VDI); Dr. C. W. Rausseadorf, *Secretary VDI*; Nelson Stork, *General Manager, Adam Opel A. G.*; Gaston de Wolff, *Assistant to the General Manager, Opel*; Hans Mersheimer, *Chief Engineer, Opel*; Gunnar Windstrom, *Manufacturing Manager, Opel*; and W. H. Worthington, *member of SAE International Information Committee.*

ITALY:

Prof. Antonio Capetti, *Vice President General, Associazione Tecnica Automobile (ATA)*; Dr. Ing. Mario Marchisio, *Foreign Delegate, ATA*; Miss Egle Crocetti, *Secretary, ATA*; Prof. Vittorio Valletta, *President, Fiat Societa per Azioni*; Dr. Gaudenzio Bono, *General Manager, Fiat*; Dr. Ing. C. F. Bona, *Director of Research, Fiat*; Dr. Luigi Locati, *Technical Director, Fiat*; and Dr. C. P. Galotta, *Assistant to the Director of Research, Fiat.*

AFTER ADDRESSING A DISTINGUISHED GROUP OF MEMBERS OF ATA (the Italian Automotive Engineering Society) in Turin, President Kucher was thanked by Professor Antonio Capetti, a Vice-President of ATA, who presided at the session.

tensive research laboratories and development programs as are the car makers and supplier companies in this country. Those European manufacturers who do have laboratories and conduct research devote themselves almost exclusively to short-term development programs. There is little, if any, activity that resembles basic research at this time. However, strides are being taken in that direction by some. A case in point is the expansion currently under way at Renault, which is increasing the size of its research center at Roueil outside of Paris. The purpose of these new facilities is to institute basic research programs there.

Test tracks are not nearly as much in evidence among the car builders as they are in this country. In England, for example, all of the manufacturers use the MIRA track, a short distance from Coventry. European car makers also do limited field testing by American standards.

A rather interesting approach to the evaluation of life of components is followed at Fiat. In the Fiat laboratories, components large and small as well as assemblies are tested in the laboratory for life and wear. The results are then extrapolated in terms of operation of the components in the vehicle. We observed a rather interesting type of crash-test at Fiat. This, too, was conducted in a laboratory. The installation consisted of a steel barrier against which an automobile was catapulted a distance of no more than ten feet. The vehicle was, of course, fully instrumented and the data gathered, we were told, gave some indication of what would happen to the vehicle in an actual crash.

There is little question in my mind that a great deal of the work being conducted in the research laboratories and engineering departments abroad would be of interest and value to engineers in our country. For example, at MIRA, I was shown an interesting project involving the work-hardening of surfaces at critical points which helps greatly to improve the life of parts. At Fiat, a new process was shown to me which is called "Tuftriding." It is a nitriding process which greatly increases fatigue limits of steel parts. It involves the fusion of nitrogen into the steel surface to form a soft outer layer. You could call this chemical prestressing in that the skin is put in compression by this heat-treating process. Right now Fiat is starting to use this process on crankshafts for diesel truck engines.

Interesting combustion studies, new material applications in plastics and rubber bonded to steel, powdered metals, fatigue studies of materials, designs for fuel economy and other work are very much in evidence in the laboratories of engineering departments which I visited.

I am certain that my visit, and the one by 1959 SAE President Raymond two years ago, will help lay the groundwork for more extensive technical interchange between engineers in our country and those in Europe. It is my feeling that SAE has a rich field to draw from in both the manufacturing and the engineering developments abroad, as well as much to give to our European colleagues. I shall try to help the Society realize these potentials as a means of better serving our members.

SAE National Meetings

1961

September 11–14
"Heavy Duty Vehicle"*
(including production forum and engineering display),
Milwaukee Auditorium,
Milwaukee, Wis.

October 9–13
Aerospace Engineering and Manufacturing
(including engineering display)
The Ambassador, Los Angeles, Calif.

November 8–10
Fuels and Lubricants
Shamrock Hotel, Houston, Texas

1962

January 8–12
Automotive Engineering Congress and Exposition,
Cobo Hall, Detroit, Mich.

March 12–16
Automobile Week
(combined National Automobile and Production Meetings),
Sheraton-Cadillac, Detroit, Mich.

April 3–6
Aeronautic
(including production forum),
Hotel Commodore, New York, N. Y.

June 11–15
Summer, Chalfonte-Haddon Hall,
Atlantic City, N. J.

August 13–16
National West Coast, Biltmore Hotel, Los Angeles, Calif.

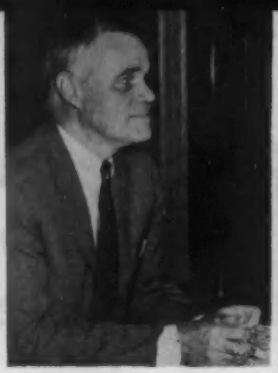
September 10–13
Farm, Construction, and Industrial Machinery
(including production forum and engineering display),
Milwaukee Auditorium,
Milwaukee, Wis.

October 8–12
Aerospace Engineering and Manufacturing
(including manufacturing forum and engineering display),
The Ambassador, Los Angeles, Calif.

October 29–November 2
Combined National Fuels & Lubricants; Powerplant;
and **Transportation Meetings,**
Bellevue Stratford, Philadelphia, Pa.

* Combined Farm, Construction and Industrial Machinery; Powerplant; and Transportation Meetings.

JACK DYMENT, chairman, SAE Engineering Activity Board.



JOHN MOXEY, chairman, SAE Technical Board.

RUSSELL CANDEE, chairman, SAE Tractor Technical Committee.

WILLIAM LUX, chairman, SAE Membership Committee.

Technical Moves FORECAST at 1961 SAE Summer Meeting

Plant trips to Carter Carburetor and Chevrolet were popular features. Attendance over 1500; technical sessions attract good audiences.

WIDESPREAD AVAILABILITY within two years of automatic transmissions for combination with light diesels was forecast at the 1961 SAE Summer Meeting at the Chase-Park Plaza Hotel in St. Louis, June 5–9. . . . Other forecasts at the 34 technical sessions combined to point the way to important technical development throughout the automotive industry — in land, air, and sea vehicles and powerplants.

VTOL capabilities were envisioned as a key to unlock greatly expanded use of business aircraft in the next few decades. Ground-effect vehicles, it was predicted, are more likely to see practical use in over-the-water operations than over-the-highway or over-the-railroad-tracks . . . a new system was revealed for detailing abnormal combustion in gasoline engines. (It involves mounting a vibration pickup on the lower engine block, near the front main bearing.) . . . And "sideways parking" has been achieved experimentally for ships.

These and scores of other technical ideas were developed in the papers and discussions at St. Louis, where more than 1500 engineer members and guests attended the sessions. Highlights are summarized in the following paragraphs.

Automatic transmission available for diesels

Fully automatic transmissions that have been available on gasoline-powered trucks since 1956 are now available for use with diesel engines. It is quite safe to forecast that in another year or so, all major truck manufacturers will have automatic transmissions available for combination with light diesels as this engine expands into multistop truck application.

The same basic concept of the automatic transmission for gasoline-powered trucks — the engineered power train, the torque converter, the automatic shift, the hydraulic retarder, and the automatic control system — is equally adaptable to diesel.

Major advantages of the automatic transmission include: proper gear ratios for highway operation, torque converter action for city stop-and-go driving, good fuel economy, and improved ease of handling that reduces fatigue, to make the work of the driver more effective.

While it is a relatively simple task to adapt the automatic transmission to diesel engines, the fact that it must be specifically matched to the engine requires extensive testing to assure compatibility. On one automatic transmission, a larger converter was selected to provide desirable speed and performance characteristics from the engine-converter combination. The capacity of the splitter clutch was increased by adding a clutch plate and modifying the return spring to compensate for the loss in centrifugal force due to lower speed operation of diesels.

Certain components in the automatic control system were modified so that the shift points of the transmission were synchronized with the speed-torque characteristics of the diesel. With this matching, the proved performance values of the automatic transmission are now available for smaller horsepower diesel engines in general applications.

The automatic transmission for diesels promises to be particularly effective in the new "powered combinations." These self-powered trucks can be coupled in tandem for over-the-road travel and later uncoupled for use as individual delivery units at their destinations. In tandem these highway "trains" will be able to utilize the power of all the trucks through the synchronizing feature of the torque converter, which is integral with the automatic transmission.

VTOL business planes coming

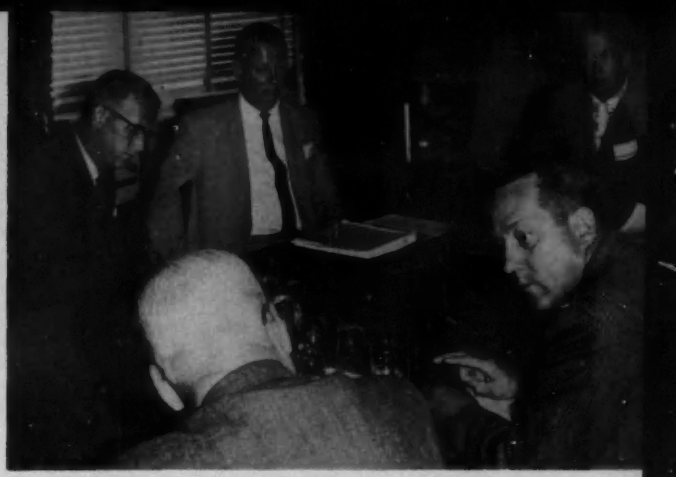
VTOL capabilities for business aircraft is looked to as a key to expanded use in the next couple of decades.

Already-integrated turbine powerplants are being developed that will act either as a jet engine for forward flight or drive submerged fans for vertical take-off and landing.

Since the ducted fan can enjoy a 3/1 thrust ratio over a normal jet engine, it's expected that the power match for the two modes of operation will be good. Rough estimates for business aircraft indicate that the match occurs

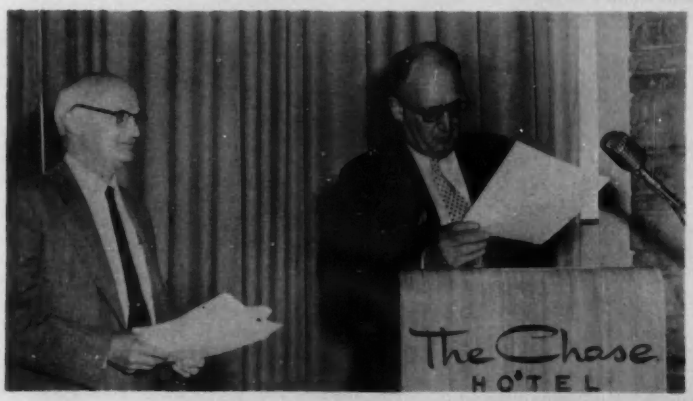
L. C. KIBBEE, chairman, SAE Truck & Bus Technical Committee.

R. R. NOBLE, chairman, presided at the meeting of the Truck & Bus Activity Committee at which final plans were made for T&B participation in the Heavy-Duty Vehicle Meeting to be held in Milwaukee in September. Plans for the 1962 Annual Meeting and other 1962 meetings were also discussed.



R. L. DOUGLAS (third from left), chairman of SAE Transportation and Maintenance Technical Committee opens discussion on tractor protection valve. Other topics covered by the Committee were: cooling system maintenance, trailer axles, dual wheel alignment, kingpin standardization, and brake test fitting location.

C. E. HABERMANN (standing) opens SAE Powerplant Activity Committee Meeting at 1961 SAE Summer Meeting. Habermann is chairman of this Activity.



F&L Technical Committee

W. S. JAMES (left), chairman of Subcommittee B — Engine Lubricants — of the SAE Fuels and Lubricants Technical Committee, gives his report while T. B. RENDEL, chairman of the main committee, listens. Rendel is also chairman of SAE's International Information Committee.

EBERHARD MAHLE (left) and DR. WOLFGANG GEBHARDT of Mahle Komm.-Ges. were visitors from Germany. Mahle is a well-known German sports car race driver, having twice been champion sports car racing driver of Germany — in 1957 and 1959. Shortly before his present trip to the United States, he was one of 80 drivers in the Nuerburg Ring race. He came in second, driving a Porsche. Both Mahle and Gebhardt attended the session on aluminum cylinder bore finishes, where Gebhardt presented a discussion.

DR. E. W. HUBER (right), Institut fur Motorenbau, checks slides for his paper, "Thermodynamic Measures Give Low Fuel Consumption and Favorable Torque-Characteristics in Automotive Spark-Ignition Engines," with PROF. W. E. MEYER, Pennsylvania State University, who actually presented the paper.

SAE SUMMER MEETING

. . . continued

at a cruise design speed of 400 knots.

Some problems that will need careful attention include: sealing wing-buried fans in foward flight, gyroscopic effect of fans, noise, thermal expansion in ducting, and high fan discharge velocities near the ground.

Measuring radiant energy from combustor flames

The radiation emitted by flames, typical of those obtained in jet engine combustors at atmospheric pressure, is not characterized by black body energy distribution. However, grey body radiation is approached with increasing pressure. Therefore, measurement of total radiant energy should include the infrared spectral region through 5 microns to obtain reliable data.

The amount of radiant energy received from the flame zone can be modified significantly through absorption by quenched combustion products. Therefore, the radiation detector should be oriented from the surface of interest.

Measurement of radiant energy from jet combustor flames is of interest because this form of energy can be a predominate factor in determining combuster liner temperature — often a cause of combustor failures.

With propellers fore and aft, ships go sideways

Did you ever wish you could park your car by moving it sideways to the curb? Shipowners have often wished the same; but they did something about it. There have been several successful experiments in fitting ships with auxiliary bow steering propellers so that they can be "broached" sideways to a dock.

Some ships requiring precise maneuverability — such as missile trackers, oceanographers, and off-shore, deep-well drillers — have already been fitted out with "bow thrusters" as naval architects call them.

One type consists of a propeller installed in a tunnel, which runs transversely through the bow of the ship. This type can exert thrust either to starboard or port.

In another scheme, a propeller is installed in a cut-out section in the bow, or it can protrude beneath the hull. This type can provide thrust in any direction and even ahead and astern if desired.

When used in conjunction with a stern-steering propeller, it is possible to turn a ship completely around within its own length. Or the ship can be slipped sideways into a berth.

Buoy tenders, dredges, ferries, ore carriers, and even large ocean-going passenger liners, both here and in Europe are being fitted with bow thrusters.

Despite the increased expense, shipowners believe it pays off by permitting a ship to operate on days when wind and seas would otherwise make maneuvering too difficult. Also, a bow thruster can aid in steering a ship through winding rivers and narrow canal locks, and in docking in ports where tugboats aren't available.

GEM's will need special roads

Wheeled automobiles, as we know them today, are not likely to be replaced by vehicles which ride on cushions of air (ground effect machines) unless extremely smooth, automated highways are specially built for them, General Motors researches indicate. While thin films of air have been used successfully to provide frictionless bearings for machinery, GM engineers say, it is doubtful whether the method can be adapted to support mass transportation vehicles. The film of air would, of necessity, be only thousandths of an inch thick and therefore the GEM would not be elevated high enough to clear even the smallest bumps in the road.

The use of existing railroad tracks was ruled out because rails have gaps between them and often they vary in height as much as one-eight inch.

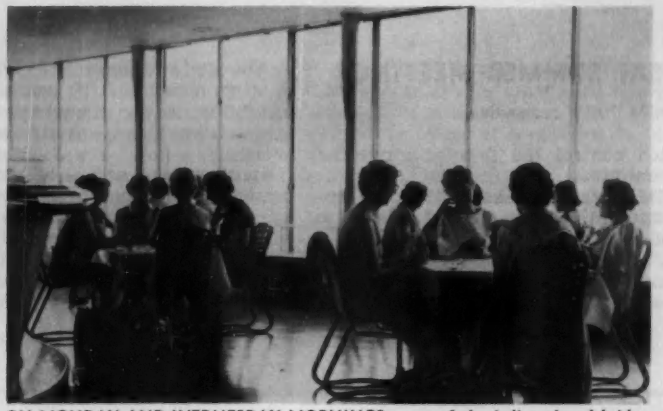
To lift a vehicle higher off the ground (by increasing air pressure at the bearing points) is not feasible because of the large amounts of power needed to maintain a thick air film.

Another approach, in which the vehicle is supported on a low-pressure cushion of air underneath the entire vehicle — instead of a high-pressure thin film at several contact points — may be feasible, according to GM researchers. This type of GEM will be able to operate with greater ground clearance and therefore will be a little more tolerant of bumps in the road.

GM built three experimental models using the air-cushion principle. They are essentially rectangular platforms, made of aluminum, with room for two people in the center. Fore and aft of the seat are large fans, driven by 15-hp engines, which force air under the vehicle. The air is prevented from escaping too quickly out the side by baffles.

The air cushion lifts the 400-500-lb machine off the ground and supports it with practically no friction between it and the ground. Thus, with comparatively little propulsion power, the vehicle can move forward at high speeds. The direction of motion is controlled by manipulating air ducts

C. M. HEINEN (right), chairman of the SAE Horning Memorial Board of Award, presented the Horning Memorial Award to WILLIAM G. AGNEW, as author of the best SAE paper in 1960 on the adaptation of internal combustion engines to fuels. Agnew's paper, presented at the Society's Summer Meeting in Chicago last year, is entitled "End-Gas Temperature Measurements by a Two-Wavelength Infrared Radiation Method."



ON MONDAY AND WEDNESDAY MORNINGS many of the ladies played bridge or canasta on the Zodiac Roof of the Chase Hotel, overlooking beautiful Forest Park. Shown here is an overall view of several of the foursomes.

H. S. VIERLING (left), vice-president and general manager, Chicago & Eastern Illinois Railroad, and H. L. WITTEK (right), director of research, Allis-Chalmers Mfg. Co., greeted DR. ICHIRO WATANABE, professor of engineering, Keio University, Japan, who attended the meeting. Prof. Watanabe was one of the authors of a paper on the effect of the exhaust pipe system on the performance characteristics of a 2-stroke diesel.

A. W. ZUB, 1960–1961 chairman of the St. Louis Section, host to the 1961 SAE Summer Meeting, and MRS. CLIFFORD R. FEILER, chairman of the ladies' activities, with CAPT. BILL MENKE, whose "Goldenrod Showboat" was the scene of the Wednesday evening social affair called the "Mid-week Mixer." The 52-year old showboat is now tied up at a Mississippi River levee in St. Louis, after a long career of one-night stands up and down the many inland rivers of the country.

SAE SUMMER MEETING

. . . continued

which control the flow of air under the vehicle.

GM tests have shown that the experimental vehicles are not as easy to control as a wheeled vehicle. Without the friction contact of wheels on the ground the airborne vehicle is easily blown about by wind gusts. Also, even on the slightest slope, the GEM tends to drift downhill. To overcome this instability, it was thought some kind of automatic driving control would be necessary.

Another disadvantage is that a GEM must use power just to hover in place, whereas an automobile is supported by wheels with no expenditure of power.

Probably if the ground effect principle is to find a place in mass transportation its potential would seem to be for use on high-speed, automated thoroughfares. The roads would have automatic guidance so as to ensure control of the vehicles, which would travel at more than 150 mph. At these high speeds it might be possible to take advantage of aerodynamic lift and to provide for ramming the air under the vehicle and to obtain additional support.

A more likely use of GEM's will probably be for over-the-water opera-

News from Committees . . .

AT NEARLY 100 administrative and technical committee meetings throughout the 1961 SAE Summer Meeting plans went forward for future activity. On every Society front promise appeared for improvement, expansion, or deeper penetration of the areas of administrative and technical interest to members.

AN INFORMAL PUBLICATION CONFERENCE during the meeting brought together for the first time representatives of all SAE groups concerned with development and distribution of SAE technical material. SAE Publication Committee Chairman Leonard Raymond was "moderator" for the gathering, where the following laid the basis for discussion by explaining the mission and work of their groups:

T. L. Swansen — for the Publication Committee (which reports directly to the SAE Board of Directors); V. G. Raviolo — for the Publication Advisory Committee of the SAE Engineering Activity Board; Harold V. Nutt — for the Publication Policy Committee of the SAE Technical Board; D. E. Manning — for the publication groups working under the direction of the Aerospace Council of the SAE Technical Board . . . and Paul F. Allmendinger for the SAE Sections Board — which, later in the week, established a Publications Advisory Committee of the SAE Sections Board.

Other representatives of the three Boards — to the number of 10 or 12 — were in attendance and participated most actively in the extensive discussion which followed the expository presentations.

SAE President A. A. Kucher was in attendance throughout the discussion and, near the end of the three-hour exchange of views, summarized as follows:

"It is apparent that our greatest need is to improve implementation of communications procedures between the various SAE groups concerned with development and distribution of technical information — whether in the form of papers, reports, symposia, books, or whatnot. . . . Just as apparently, we are already well equipped with individual groups to develop ever-better material — and with publication and meeting outlets for getting the developed material to members.

"So, I suggest that the Board of Directors be asked to name a small committee representative of the groups which have participated in this 'informal' conference. And, I suggest this small committee be asked to study and **recommend establishment of new and improved communication channels** to permit fully active functioning of ALL SAE publication procedures."

Later in the week, the SAE Board of Directors authorized appointment of such a group, the suggestion having been brought to the Board by Publication Comimttee Chairman Leonard Raymond on behalf of all the "conference" groups.

Still later, President Kucher named the following to the new "ad hoc" study group: Leonard Raymond, chairman; V. G. Raviolo, T. B. Rendel, Roy P. Trowbridge, D. E. Manning, Paul F. Allmendinger, F. B. Esty, and T. L. Swansen.

●

THE SECTIONS BOARD named a Publications Advisory Committee of the Sections Board at its St. Louis meeting. In doing so it acted on the recommendation of Sections Board Chairman Paul F. Allmendinger, who for several months had been actively studying the need for such a group. His recommendation included definition of the function of the new SB Publications Advisory Committee as twofold: (1) to devise and implement means by which individual Sections may be assisted in improving the technical content of their papers; and (2) to establish a review committee to read and evaluate technical papers presented before Sections to determine their suitability for publication as SAE Preprints. F. B. Esty was named chairman.

Allmendinger

Esty

●

The SAE TECHNICAL BOARD decided in St. Louis that the best place in SAE to set up a Hydrofoil Technical Committee is under the Board's Aerospace Council. Evidence of need for technical committee work in this area seemed clear.

●

"We would be taking a step in advance," quipped one veteran Section officer, "if every Section Governing Board would devote as much time and effort to developing its technical meetings program as it does to its one Ladies' Night meeting."

tions where the "roadbed" has no hills. It is known that the military services are interested in the over-the-water and amphibious possibilities for GEM's.

System detects abnormal combustion

A new system for detecting abnormal combustion in a gasoline engine involves mounting a vibration pickup on the lower engine block near the front main bearing. The blow delivered to the power train by the excessive pressure of abnormal combustion can be detected without other engine vibration interference.

By combining this technique with the more conventional use of pressure pickups in each cylinder of a special 11/1 compression ratio GM research engine, it has been found possible to measure the smoothness of combustion of various fuels. In testing pure hydrocarbons, it was found that isooctane and xylene gave very smooth combustion, while toluene, often taken as representative of aromatics in fuel, was very rough.

More conventional fuel blends were using heavy catalytic reformate (aromatic), light catalytic distillate (olefinic), and light alkylate (paraffinic) with two types of tetraethyl lead. Highly aromatic or paraffinic fuels tended to give smooth combustion,

around the Summer Meeting

A SPECIAL MARINE STUDY COMMITTEE has just been set up by the SAE Technical Board's Automotive Council to "determine what SAE objectives should be in marine standardization and how these objectives may best be attained. . . . Led by W. C. Conover, Outboard Marine Corp., as chairman, this Marine Study Committee started its investigations by meeting with participants from several associations and agencies of the marine industry on June 15.

●

At the Engineering Education Activity Committee session it was said that:

- **Only five schools did not require any graphics of any kind.**
- **Engineering students are now receiving less prepartion in graphics than in past year.**
- **Further reductions in required graphics are being made and more are indicated.**

●

"BECAUSE the SAE Enrolled Student program is the largest single source of new SAE members, we shall concentrate much of our membership efforts in the immediate future in this direction," Membership Chairman W. J. Lux reported to SAE Directors in St. Louis.

●

PARKINSON'S LAW WAS REVERSED when Chairman Clayton Lewis asked the Engineering Activity Board to disband his Nuclear Energy Activity Committee. "The other Activities are getting nuclear energy techniques into their programs," said Lewis, "so there's no need for a continued 'stimulation'." . . . The EAB gave the NEAC a rousing vote of thanks for the fine job it has done — and for keeping the roster clean of "suspended-animation" committees.

"HOW BEST can an engineer's education be continued after he has left college?" started a vigorous exchange of opposing ideas at the first meeting of SAE's new Engineering Education Activity. Result: this will probably be among the topics to get panel-meeting airing under EEA sponsorship sometime. . . . Many interesting ideas and facts crossed the table at this kickoff committee meeting at which Chairman Joseph P. Mikita (seated, left center) presided. Engineering Activity Board Sponsor for the EEA, Professor Phillip S. Myers of Wisconsin (seated, right center) outlined the Committee aims to start. In attendance also were Committeemen Lamont Eltinge, American Oil Co., (standing, left); Prof. Donald R. Olson, Yale University (standing, center); Dr. Walter T. Olson, NASA (seated, right); Prof. Ernest Starkman, University of California (standing, right); Prof. Jay A. Bolt, University of Michigan, (seated, left) who represented his confrere, Prof. Gordon J. Van Wylen, University of Michigan. Hollister Moore, manager, Sections and Membership Division, SAE staff, is serving as staff representative for this Committee.

●

THE SAE TECHNICAL BOARD requirement that all standards must be reviewed at least once in every five years, applies also to manuals and similar technical material growing out of SAE technical committees, General Standards Council Chairman G. E. Burks reminded at the Board's St. Louis meeting.

SAE SUMMER MEETING

. . . continued

while olefinic types were most prone to surface ignition and engine roughness. The lead type had negligible effect.

Using these techniques, engineers expect to learn more about combustion processes and the contribution the various components make in a blended gasoline as far as smoothness of combustion is concerned.

Ship engine rooms going automatic

The day when ships will have completely automated engine rooms may not be too far off. The trend is toward more sophisticated control systems. This will help engine manufacturers give the ship owners more engine for their dollars and ensure reliable operation with a minimum cost.

For example, to get long life from engines, engine builders specify that it be operated below certain speeds and firing pressures. Because human engineers sometimes make mistakes, a large safety factor must be included in the specifications. With fully automatic controls this safety factor may be reduced and it will be possible to take more horsepower from the engine;

News from Committees . . . around the Summer Meeting

Sadler

THE AEROSPACE COUNCIL of the SAE Technical Board is actively encompassing the era of expansion into missiles and space engineering. At the same time that Aerospace Council technical committees have been broadening and deepening service to the aeronautic industry, the Council has established itself as the agency for doing a substantial amount of work on items in the missile field. . . . And, according to Council Chairman Carl Sadler, specific items in the space-engineering area are to come in due time.

●

GOVERNMENT-requested, SAE-developed reports are slated to get special treatment as a result of Technical Board action. A special GR (government report) classification and a separate published outlet is now in existence for Standards and Recommended Practices on materials, parts, and equipment that are specifically for government equipment application.

●

FIVE NEW Section Coordinators appear on the list of 15 who will carry on the second year of this most successful Sections Board innovation of 1960. . . . Charged with responsibility for helping designated groups of Sections, this group has been active and well-received. The NEW coordinators — and the Sections which they will assist — are: L. P. Livingston (Texas, Texas Gulf Coast, Southern Texas); C. A. Dillinger (Oregon, Northwest, Alberta, British Columbia, Spokane, Intermountain); W. H. McGlade (Central Illinois, St. Louis); E. D. Hendrickson (Chicago, Fort Wayne, Rockford-Beloit); and I. M. Harlow (San Diego, Southern California, Salt Lake, Hawaii).

●

USEFUL ADDITIONS to SAE vocabularies heard during the meeting:

"If we don't make a specific request, we might **committee-the-hell-out-of** this whole program."

"You've got to decide if you want a paper on this subject that has something worth-while for the expert, or if you're just after a **junior-executive-type presentation.**"

Membership Committee Chairman W. J. Lux — reporting a membership loss of only 138, despite the dues increase — says he was "pleased with the hard work of the committee people" but views the results with **"optimistic dissatisfaction."**

●

STUDY IS ABOUT TO BE MADE BY THE AEROSPACE COUNCIL of the possibility of SAE technical committee work on value analysis in aerospace industries. Aerospace companies, it is understood, have been getting many letters and requests from the Government asking them to do individual studies in this area.

●

A PAN-AMERICAN DAY is scheduled to be a highlight of the 1962 SAE Annual Meeting . . . which, incidentally will probably be designated again as an Automotive Engineering Congress and Exposition. Plans are to deal with problems experienced by Latin American engineers and by U. S. engineers in Latin America. . . . The papers and discussion will be aimed to educate United States' engineers about South American ground and aerospace engineering problems and requirements . . . in the hope of better equipping them to cooperate with South American engineers in the latter's efforts to solve their own problems.

●

SAE PRESIDENT A. A. KUCHER scored a major hit at every one of the various committee meetings where he related interesting incidents from his recent trip to England, France, West Germany, Switzerland, and Italy — as SAE President. A more formal story of his official visits and signicant exchanges with overseas engineers starts on p. 106 of this issue.

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SPEEDING UP of SAE membership approval-or-rejection procedures caught the attention of the SAE Board of Directors at its St. Louis meeting. During the next few months, the Directors plan to look for possible ways to expedite the current review procedures.

●

AN AUSPICIOUS START was given to the 1961 SAE Summer Meeting by the "Welcome Reception" staged on Sunday evening by the St. Louis Section. It fully lived up to its billing as "an opportunity to renew old friendships and make new ones." . . . Retiring St. Louis Section Chairman Albert W. Zub joined with his 1961–1962 successor, William L. Galbert, and other Section members as hosts to the large number of early arrivals.

thus reducing operating costs without increasing maintenance costs.

Many cases can be cited where automatic control is already an accepted practice. Highly maneuverable naval vessels such as subchasers, ice-breakers, and ships which use their engines to drive dredge pumps require controls to protect their engines when speed is changed rapidly. Governors are used to measure the speed and cut back on the fuel when necessary.

Some passenger ships use automatic controls to synchronize engines to reduce vibrations and noise.

A new marine governor is coming into use on large European engines which drive the propeller directly. It limits the amount of fuel for each propeller speed. When the propeller comes out of the water in heavy seas, necessary adjustments are made so that the engine doesn't overspeed.

Engine speed and propeller pitch are often controlled remotely from the bridge. This gives instantaneous control of power and has improved ship maneuverability and safety. It has also enabled ship owners to reduce engine room personnel.

Fully automatic control of speed and propeller pitch is also in use.

We can expect to see more and more sophisticated automatic control systems in the future. In fact, it has been hinted that one particular system is contemplated that involves a completely automatic engine room.

Thicker skins protect against lightning

Lightning-strikes on aircraft will not penetrate skins over 0.032 in. thick, previously unpublished tests on commercial transports show. This sets at least one design minimum for panels on aircraft where there is potential danger of igniting gas or turbine-fuel vapors.

Reliability program depends on people

Success for a reliability program depends most on the reliability of the PEOPLE involved in carrying out the program. The need for reliability of the people involved "stands out above every other element, and influences every other element," said one manufacturing executive — and others agreed. And among the "people," discussion indicated, the foreman or the immediate supervisor is the key man. It is desirable to establish in the foreman's mind his responsibility for quality and will as quantity results; to let him see the results of the work of his department — good or bad — in terms of reports from the field after the product is in service. Then, he can play a major and effective part in selling responsibility for reliability to each of the men who work for him. "It is through the immediate supervisor," one production manager summarized, "that we must reach the individual worker and instill in him the pride of workmanship and initiative; make him realize his interest in reliability is an important spoke in the wheel of his own as well as of his company's success."

There was a tendency in this discussion to see reliability as a result of a modern quality control program, rather than as a totally new kind of program. Even those who took this view, however, admitted that many current reliability programs probably go farther than even modern quality control programs in some respects . . . while others left the meeting still feeling that a quality control program is merely an important segment of the much broader programs to which the term "reliability" has come to be attached.

The cost of making a product right the first time is the only true cost, it was brought out. All additional costs of reworking, modifying to suit customer desires; and so forth are candidates for potentials savings.

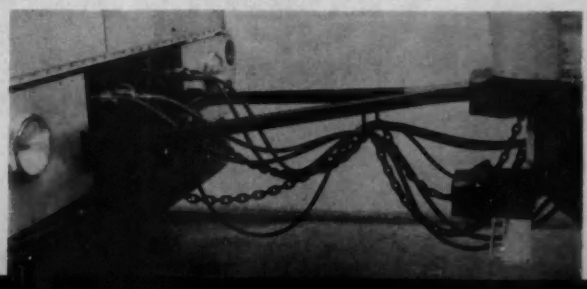
Quality must be attacked by all personnel within a given area, it was agreed. Every worker as well as every supervisor must collaborate in a team effort if methods and qualities are to be improved.

THIS FLYING PLATFORM, skimming across water on a cushion of air, may have possible use for amphibious operations; but it is not likely to replace the automobile because it requires extremely smooth road surfaces. The air cushion on which it rests is formed by two fans, fore and aft of the driver, which suck air through the craft and force it underneath. This "ground effect machine" was developed by GM Research, and described at the Summer Meeting.

THE NEW WOLFWAGON — a double-duty pickup and delivery truck and intercity vehicle manufactured by St. Louis Car Co., was at the meeting.

As shown, they are separate, self-powered trucks that can be coupled together, with one driver in the front unit, controlling all engines.

Heart of the equipment is a sensing valve in the lead unit and a vacuum pump driven by each towed unit engine, which provides throttle control. The sensing valve determines the amount of throttle opening required by the lead unit. This requirement is signaled to the towed units and the throttles are opened a proportionate amount. A hand-control valve provides complete override of the automatic throttle system.



Carter Carburetor

CARTER CARBURETOR'S ST. LOUIS PLANT was visited by 75 interested engineers on Tuesday morning. During the three-hour tour the group was able to visit a variety of departments, where they saw methods of die casting, machining of zinc and aluminum die castings, use of manufacturing techniques on interchangeable parts, assembly operations, testing, and quality control. The plant covers two city blocks, is four stories high in some parts, and, at peak periods, employs about 2500.

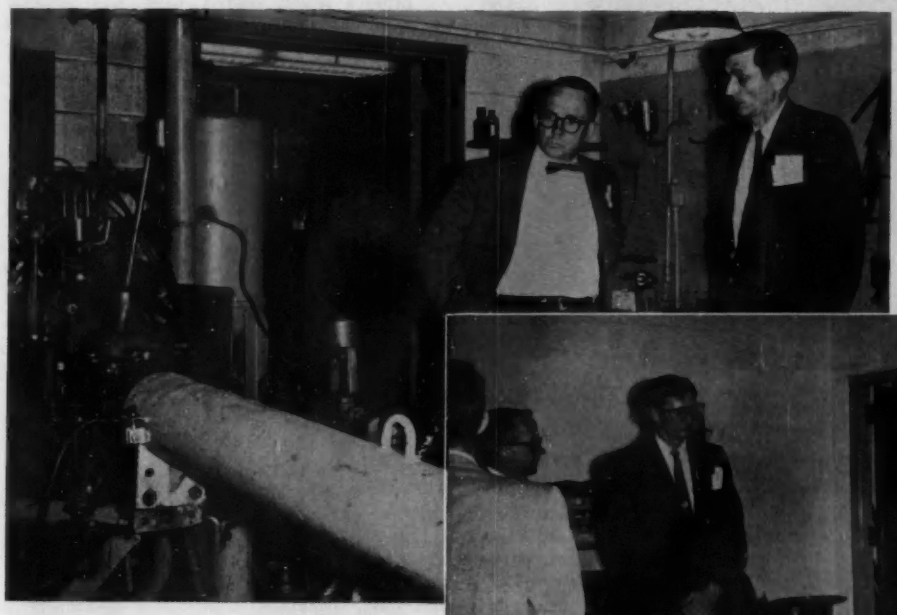
SUMMER MEETING PLANT TOURS SUMMER MEETING PLANT TOURS SUMMER

Corvette Assembly Plant

CORVETTE CHASSIS AND BODY buildup and final assembly operations were witnessed at Chevrolet's St. Louis plant. Chevrolet Greenbrier and unitized pickup truck assembly operations were also watched.

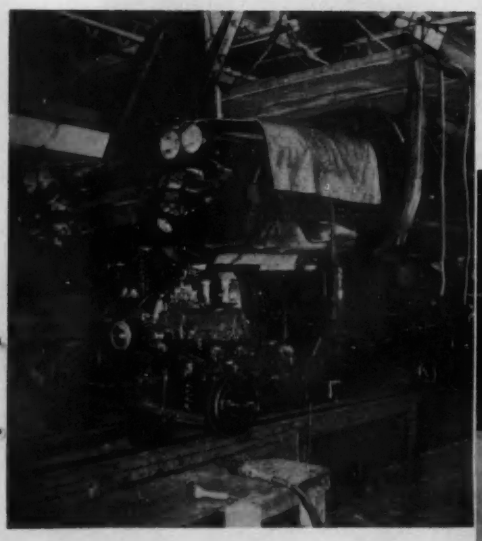
Monsanto Chemical

MEMBERS OF LOST CONTINGENT inspect new Monsanto facilities on outskirts of St. Louis. Bus driver accidently took them to wrong plant for tour of Research Laboratories of the Organic Chemicals Division. Two hours late, and after a pleasant trip through St. Louis and surrounding suburbs, SAE'rs reached destination for enlightening tour of the labs.



SAE'rs INSPECT ENGINE TEST CELLS at Research Laboratories of Organic Chemicals Division of Monsanto Chemical Co. Oil and gasoline additives are evaluated at Applications Laboratory. Members also visited High-Pressure Laboratory and Research Library.

MEETING PLANT TOURS SUMMER MEETING PLANT TOURS SUMMER MEETING



Rambling through

At a recent meeting to mark the close of the NORTHERN CALIFORNIA Section year (left to right) are Forest Fingerle, South Bay Division chairman; I. M. Harlow, Section chairman; and Percy Harmon, SACRAMENTO-STOCKTON Division chairman.

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PROS AND CONS OF MULTIVISCOSITY OILS — extended lubrication periods — ash-free motor oil additives — and possibilities of higher compression ratios requiring more suitable fuels — were subjects aired at the April **ST. LOUIS SECTION** "stump the experts" program. G. K. Malone of GM Research Laboratories; M. O. Jefferson of Socony; and M. A. Remondino of Ethyl were the panel . . . which started off the session with individual short talks on some aspects of automotive-equipment-fuel-lubricant relationship. Shell Oil Co.'s R. G. Tuell was moderator.

The May meeting was sponsored by the Section's Diesel Engine Activity . . . and featured its Vice-Chairman Frank E. Pipe of Cummins as speaker. In his paper "Recent Basic Developments in the Medium HP Deisel Engine Field," he reviewed the many aspects of diesel performance and compared them with those of the gas turbine in its present development stage.

•

AT HAWAII SECTION'S May meeting are (left to right) Tom McLaughlin, Ford Motor Co.; Larry Grant of the Honolulu Auto Center; and Morito Tsutsumi, retiring Hawaii Section chairman.

McLaughlin spoke to the Section on "What's Happened to the Ford Truck Since the Model T." Featherstone talked on "Evaluating Diesel Power for Motor Trucks."

BY 1965, IT IS ANTICIPATED that the specific output of Caterpillar's 1673 diesel truck engine can be doubled by going to bmep's much higher than the present range of 157–170 bmep. Now, it produces about 0.35 bhp/cu in. displacement at 1000 rpm and consumes about 0.4 lb of fuel/bhp hr . . . according to J. G. Edwards, chief engineer of Caterpillar's Industrial Engine Plant, in a recent talk before **NORTHERN CALIFORNIA SECTION.**

At the Section's **SACRAMENTO-STOCKTON DIVISION** meeting, Boeing's B. C. Karther told of development of the 502 gas turbine . . . which in drone aircraft allows speeds of 400 mph at 40,000 ft. In the City of San Francisco's new fire truck, he said, it develops 330 hp with a weight of 335 lb.

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NEW NORTHERN CALIFORNIA SECTION Chairman E. S. Starkman (left) presents a certificate of appreciation to outgoing Chairman I. M. Harlow.

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SIGNIFICANT IN DEVELOPMENT OF THE POWER TURBINE STAGE — and key to its performance — is the variable second stage nozzle mechanism . . . which allows continuous automatic variation of the nozzle blades with gas generator and vehicle speed. This and other facets of Chrysler's multifuel regenerative gas turbine (CR2A) were described by George J. Huebner, Jr. at a recent meeting of the **ONTARIO SECTION** in Windsor.

the Sections

Northwest Section hears all about Air Transport

NORTHWEST SECTION'S Annual Aircraft Meeting — devoted this year to air transport topics — drew more than 300 members and guests to its three sessions and banquet at the New Washington Hotel in Seattle. Federal Aviation Agency's Administrator N. E. Halaby was banquet speaker.

Air Cargo

At the morning session — chaired by American Airlines' Vice-President William Littlewood — Pan American's R. W. Blake told of the initiation of Boeing's 707-121 and subsequent models into its fleet, and of the problems encountered in getting the aircraft to arrive on time at a given specific-service point without deadheading the craft. The difficulties of the air cargo people were aired by Eastern Airlines' Charles Froesch in his paper (delivered by G. H. Pearson). Some suggested solutions, such as specialized high-speed cargo handling to make air transportation more attractive for all kinds of freight, were presented. Seaboard & Western Airlines' J. T. Farrah spoke on the ideal cargo plane. In commenting on the loading-unloading phase, he called special attention to the pallet type being used on the Canadair CL-44.

In-flight Collision Avoidance

The afternoon panel session on in-flight air collision avoidance — consisting of American Airlines' William Littlewood, FAA's W. Muncey, and Boeing's Ralph Irwin and E. I. Pina — was chaired by United Airlines F. J. Todd. Each panel member dealt with one phase of preventive work being done, but all agreed that, as yet, no sure-fire, simple method has been evolved. A paper by Alexander Winick, FAA's Navigation Branch chief, wound up the afternoon session. In the course of his discussion on reliability of present equipment in zero-zero operation, Winick pointed to England's flare-out system as an outstanding example of today's best. However, he said, it is only through such evolutionary steps that zero-zero operation will really come about.

Halaby on FAA Philosophy

Federal Aviation Agency's Administrator N. E. Halaby, banquet speaker, was introduced by toastmaster Maynard Pennell of Boeing. Halaby told of the philosophy of FAA in establishing airway regulations, and explained the roles of FAA's "Beacon" and "Horizon" Committees as planning media — in terms of the next ten years.

Federal Aviation Agency's Administrator N. E. Halaby — accompanied by Mrs. Halaby — arrives at Seattle Airport to address Northwest Section's Air Transport Meeting banquet.

SAE MEMBERS

RALPH H. ISBRANDT has been elected vice-president — automotive engineering and research, American Motors Corp. Isbrandt has been director of automotive engineering for American Motors since 1956. He is a member of SAE Board of Directors.

MERRILL A. SCHEIL has received a citation from the University of Wisconsin. The citation recognizes the eminent professional services of Scheil for outstanding accomplishments as engineer, author, and administrator.

EDWARD N. COLE, vice president of General Motors Corp., and general manager of Chevrolet Motor Division, received an Honorary Doctor of Science Degree from Wayne University recently. Cole was cited for his "major roles in the redevelopment of modern automotive engineering and styling."

Speaking at Wayne State University Engineering Honors Convocation where the degree was awarded, Cole stressed the pooling of industrial and educational scientific manpower to help stimulate new industry in Michigan . . . with resultant new products and new markets for the future.

Isbrandt

CHARLES J. CASALEGGI has become staff engineer for Purolator Products, Inc. He was formerly engineer in charge of product design for Purolator.

EDWARD W. P. SMITH has been appointed director of purchases at Bendix-Westinghouse Automotive Air Brake Co. He was formerly purchasing analyst for Bendix-Westinghouse.

ROBERT D. PETRIE has been appointed manager of contract sales for the Commercial Sales Division of American Bosch Arma Corp. He was formerly service sales representative for American Bosch.

EDWARD B. CAPLISKI has been appointed manager of the New York Regional Branch of the Commercial Sales Division of American Bosch Arma Corp. He was formerly assistant manager of the New York Regional Branch.

ROBERT W. SMITH has been appointed European technical representative for International B. F. Goodrich Co. He was formerly manager, automotive engineering section, Field Engineering Department, B. F. Goodrich Tire Co.

Smith is a member of SAE Passenger Car Activity Committee.

WALTER R. VIGNINI, formerly supervisor, product engineering for Sonotone Corp., has been appointed chief engineer in charge of engineering and product development for Sonotone.

LEONARD P. RICHARDSON has been appointed West Coast sales engineer for The Lubrizol Corp. He was formerly manager, wholesale sales at Richfield Oil Corp.

Richardson served SAE as vice-chairman of Passenger Car 1959–1960; Fuels and Lubricants, 1960–1961 and Transportation and Maintenance, 1961–1962 for the Southern Calif. Section.

R. E. HUNT will serve Ford Motor Co.'s Tractor Operations as general manufacturing manager with responsibility for manufacturing planning. He was formerly assistant general manager of Ford's Tractor and Implement Division.

ROBERT P. KNIGHTON has retired as superintendent of Esso Standard's Virginia-West Virginia Area garage in Richmond. Knighton is retiring after mechanical and supervisory service with Esso since 1922.

WILSON KOKALARI has been appointed design engineer for Convair (Astronautics) Division of General Dynamics Corp. Kokalari was formerly affiliated with Gibbs & Hill, Inc. as mechanical engineer.

EDWARD G. BENYA has been appointed managing engineer — flight test for Chrysler Missile Division, Chrysler Corp. He was formerly assistant general superintendent, assembly & mechanical fabrication, Defense Operations Division, Chrysler Corp.

Scheil

Cole

Casaleggi

Smith

Petrie

Capliski

CARL J. OLDENBURG has been named Eastern sales manager, petroleum chemicals for the Oronite Division of California Chemical Co., subsidiary of Standard Oil Co. of Calif. He was formerly Oronite's Midwestern district sales manager.

CARL W. LEMMERMAN has become sales manager of the Acoustics and Instruments Division of The Korfund Co., Inc. He was formerly president, C. W. Lemmerman, Inc.

F. C. SCHULZE has been made vice-president of sales for the Waukesha Motor Co. He was formerly general sales manager of Waukesha since 1949.

GENE H. WHITE has been appointed marketing director and sales director of Sloan Co. He was formerly staff engineer, launch control systems of Lockheed Missile Systems Division.

FRANCES L. WEEDEN, a member of the SAE staff since 1946, has left the Society's employ to be married. She and Harold J. Gibson, technical director of the Ethyl Corporation's Detroit laboratories, plan to wed in September and make their home in Farmington, Mich.

ARTHUR B. BILLET, senior staff engineer with Vickers, Inc., Division of Sperry Rand Corp., has been elected president of the Institute of Environment Sciences. Billett has been a vice-president of the national organization for the past five years.

FRED H. EDGAR has been appointed division vice-president — aluminum sales of the Metals Division of Olin-Mathieson Chemical Corp. He was formerly regional aluminum sales manager in Detroit for Olin-Mathieson.

FRANKLIN WALTER has been named director of products and chief engineer, Plymouth Division, Chrysler Corp. Formerly he was chief, styling, planning and administration for Chrysler.

RICHARD H. SHAFER has become mechanical design engineer, maintenance department for the Autonetics Division of North American Aviation, Inc. He was formerly air conditioning maintenance engineer.

J. E. KUBACKA has retired from GM's Fisher Body Division, where he was senior engineer in charge of the experimental and development department. A member of SAE since 1921, he plans to "continue to participate in SAE activities to the extent that I can when not traveling." His home is at 31100 Stafford Drive, Birmingham, Mich.

HENRY FORD II, chairman of the board, Ford Motor Co., was elected president of the Automobile Manufacturers Association at the organization's annual meeting of members.

Ford succeeds **L. L. COLBERT,** chairman of the board and president, Chrysler Corp., who has held the office since 1958. Colbert continues as a member of the AMA Board of Directors.

Other AMA officers elected were:

JOHN F. GORDON, president, General Motors Corp. — vice-president.

J. N. BAUMAN, president, The White Motor Co. — vice-president.

W. C. SCHUMACHER, executive vice-president, International Harvester Co. — secretary.

GEORGE ROMNEY, president and chairman of the board, American Motors Corp. — treasurer.

Re-elected to the Board of Directors for a 3-year term was: **ROY D. CHAPIN, JR.,** executive vice-president, American Motors Corp.

Another director was: **ROBERT F. BLACK,** chairman of the board, The White Motor Co.

JOHN F. JONES, formerly chief engineer of Williams Research Corp., was named engineering vice-president.

WILFRED H. SHAW, formerly product manager — engine controls, Hamilton Standard Division, United Aircraft Corp., has been appointed member technical staff for Space Technology Laboratories, Inc.

KENNETH C. BELL and **FRANK M. KITTREDGE** have been appointed chief spark plug engineer and section engineer respectively in The Electric Autolite Co.'s spark plug division. Bell was formerly section engineer and Kittredge was affiliated with White Motor Co.

ALEXANDER J. SZABO has been named division supervisor, Vibratory Finishing Division, Pangborn Corp. Formerly he was district sales engineer for Pangborn.

ROGER A. PEIRCE, who formerly served Sinclair Reasearch, Inc. as engineer, has been appointed assistant buyer for Sinclair Refining Co.

WILLIAM H. REINHOLD, JR., formerly director — research & development for Highway Trailer Industries, Inc., has been made member technical staff at Space Technology Laboratories, Inc.

JAMES C. PORTER has been appointed head of the research and engineering department of Hawthorn Finishing Co. He was formerly head of the mechanical section of the R&E Department of Hawthorn.

ERICH A. HEROLD, formerly assistant factory manager for Republic Aviation Corp., has been appointed manager of manufacturing planning for Sanders Associates.

C. NEIL MOULTON, formerly assistance engineer, South Dakota Highway Department, has been named mechanical engineer for the Chemical Propulsion Division of Hercules Powder Co.

DAVID W. BERRY has been appointed director of engineering — consumer products for Westinghouse Electric Corp. He was formerly chief engineer — Aviation Gas Turbine Division, Westinghouse Electric Corp.

PHILIP J. PASSON has become liaison engineer — reliability engineering supervisor for Chevrolet Motor Division, GMC. He was formerly resident engineer — Corvette — Chevrolet Motor Division.

DAVID M. BORDEN has been appointed chief engineer, automotive research for Chrysler Corp.'s Engineering Division. He was formerly assistant chief engineer, gas turbine research for Chrysler Corp.

Edgar

Oldenburg

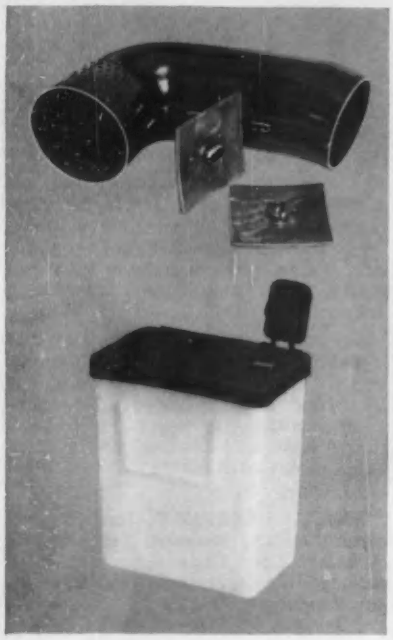
Lemmerman

Schulze

White

Weeden

Billet



Spring silencers, heater ducts, and washer jars made of MARLEX* are low cost... improve performance

Tough, long-lasting, graphite-impregnated interleaf spring silencers . . . flexible and rot-proof heater ducts that resist tears and punctures . . . light, durable windshield washer jars that won't shatter or burst, and are unaffected by freezing or under-the-hood temperatures! These three original-equipment items are examples of the ever-increasing number of automotive components being made of MARLEX high density polyethylenes and ethylene copolymers.

The advantages of using these high density plastics are many—better performance, economy, easier assembly, and molded-in texture and color if required. Physically, MARLEX high quality plastics are light, tough, corrosion- and rot-proof, non-allergenic . . . resistant to acids, alkalies, oil, and grease . . . unaffected by extremes of temperature (-180°F to 250°F).

For more information on MARLEX, see your plastic fabricator . . . or contact us directly.

PHILLIPS 66 MARLEX PLASTICS

*MARLEX is a trademark for Phillips family of olefin polymers.

PHILLIPS CHEMICAL COMPANY
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WALTER F. VELGOT, JR., Curtiss-Wright Corp.'s Aeronautical Division field service engineer, received a plaque citation from Italy's Alfa Romeo Corp. for his three years of technical assistance at their aviation facility in Pomigliano, near Naples. Velgot has been in the field of aeronautics for over 24 years.

JAMES G. BROWN has been appointed engineer, structural dynamic test for The Martin Company. He was formerly product programming staff analyst at Chrysler Corp.

LEON H. FISH has been appointed manager of Solar Aircraft Co.'s Dayton, Ohio branch office. He was formerly president for Carlson & Associates, Inc.

ROBERT W. LASHER has been appointed systems engineer, Systems Engineering Division, Filtron Co., Inc. He was formerly reliability and quality assurance engineer, Systems Division, Bendix Corp.

DON W. SHERMAN has become president of his own company, Don Sherman, Inc. He was formerly president of A. O. Smith Engineering Service Corp.

JAMES R. MAY has become assistant chief engineer — accessories for the Allison Division of General Motors Corp. He was formerly chief engineer, aeroproducts operations, Allison Division, GMC.

R. DOUGLAS SMITH, formerly manager, program control for General Electric Co., has been appointed manager — systems integration department, Aeronutronic Division of Ford Motor Co.

STEPHEN L. WYTHE has joined the Enjay Chemical Co. as product manager of the company's Paramins Division. Wythe was formerly head of the Additives Division of Esso Standard's Bayway Refinery.

LAWRENCE R. HAFSTAD, General Motors Corp. vice-president in charge of research laboratories has been elected a trustee of Johns Hopkins University, Baltimore.

MARVIN WHITLOCK has been appointed vice-president — line maintenance for United Airlines, Inc. He formerly served Capital Airlines, Inc. as senior vice-president — operation and maintenance.

H. CLARE SHEPARD, formerly sales engineer for Timken Roller Bearing Co.'s Automotive Division has been appointed sales promotion manager for Timken.

HAROLD E. WELLS has been appointed powerplant group engineer for Vertol, Division of Boeing Airplane Co. He was formerly engine manager, landing gear controls, National Water Lift Co.

HAROLD T. HOKANSON has been named vice-president — space operations for Communication Satellites, Inc. He was formerly manager, special projects for General Electric Co.

WILFORD E. SMITH has been named senior research engineer at the Missiles and Space Division of Lockheed Aircraft Corp. He was formerly chief design engineer for Bernco Engineering Corp.

CLYDE H. SCHAMEL has been appointed senior engineer in charge of Fisher Body's experimental and development department. Formerly he was engineer in charge of mechanical design section for GMC's Fisher Body Division.

FRANK G. DALEO, who was formerly program manager of commercial sales at Kollsman Instrument Corp., has joined Astek Instrument Corp. as sales manager.

J. G. SWAIN, vice-president of the Waukesha Motor Co., has announced his retirement. He will continue to serve Waukesha as director.

Obituaries

HENRY W. ALLINGHAM . . . (M'20) . . . director and owner, Vehicle Developments, Ltd. . . . died December 26 . . . born 1882.

RALPH P. DENISON . . . (M'28) . . . retired . . . died April 26 . . . born 1894.

J. A. FOSS . . . (M'41) . . . manager, Eastern Division, American Bosch Arma Corp. . . . died April 15 . . . born 1905.

J. GEORGE OETZEL . . . (M'29) . . . consultant . . . died June 19 . . . born 1894.

ROBERT S. PLEXICO . . . (M'20) . . . retired chief truck designer, Chevrolet Motor Division, GMC . . . died May 10 . . . born 1897.

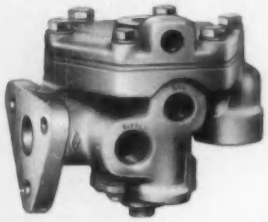
PROTECTING YOUR AIR BRAKE INVESTMENT. Outstanding example of protection in the animal kingdom is the way mother bear watches over her cubs. By far the best way to protect your air brake investment is to specify Bendix-Westinghouse. For there's an important difference in air brake performance, quality and reliability—and it's in favor of Bendix-Westinghouse. So, when you're in the market for air brakes, look at the record. It shows that, in 38 years of air brake leadership, we've always built to highest quality and performance standards . . . not just to a price. And our customer service, developed through close and constant touch with the transport industry, is another important benefit you enjoy with Bendix-Westinghouse. It all adds up to the fact that you get more value-per-dollar from Bendix-Westinghouse Air Brakes—the product and name you can trust.

SPECIFY COMPLETE AIR BRAKE SYSTEMS BY *Bendix-Westinghouse*

BENDIX-WESTINGHOUSE AIR BRAKES®

Built with the operator in mind:

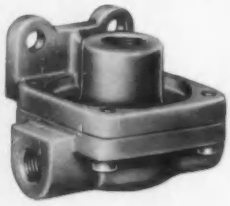
NEW BENDIX-WESTINGHOUSE COMPONENTS COST LESS TO BUY . . . LESS TO MAINTAIN



R-5 RELAY VALVE—New design, high capacity, piston type with replaceable insert. Superior performance and reliability. Responds immediately to all application and release pressure demands.

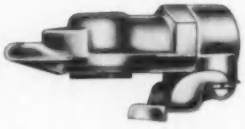
RE-4 RELAY EMERGENCY VALVE—Piston type valve. Fast application and release. Optimum synchronization of tractor and trailer brake systems. Three-minute service with RE-4 replacement insert.

TC-2 BRAKE VALVE—Trailer control valve accommodates any mounting requirement . . . steering column, remote, or dash . . . conventional or dished wheel. Replacement insert for simple maintenance.

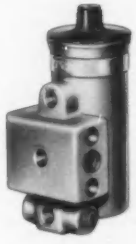


QR-1 QUICK RELEASE VALVE—Quieter, faster. Low pressure differential and increased exhaust capacity. Performance characteristics help cut brake lining wear.

E-2 BRAKE VALVE—Smooth operation, comfort level mounting, minimum effort required. Simplified design, lighter weight. Insert assembly for on-the-vehicle servicing.



ALUMINUM HOSE COUPLING—Lighter in weight. Will not chip, crack, or bend. Stainless steel contact strip assures long service life. Interchangeable with all other types.



D-2 GOVERNOR—Compact, lightweight, improved design . . . remote or compressor mounting. Faster snap action. Provides positive operation at both high and low temperatures.

MAKE YOUR AIR BRAKE DOLLARS GO FARTHER—These new system-engineered Bendix-Westinghouse products save you money in both first cost and maintenance cost. They are designed, engineered, and manufactured to the highest quality standards to provide long, satisfactory performance. And ultimately, when maintenance is required, as it is on all mechanical products, these components are simple and inexpensive to service. For instance, a design feature enables a mechanic to remove and replace the major operating section of most of these valves in a matter of minutes . . . and at the very low cost of a Bendix-Westinghouse insert assembly. This helps increase operating efficiency by reducing downtime and the cost of both parts and labor.

Modernize the air brake system on your vehicles. Ask your Bendix-Westinghouse Distributor for complete details today!

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continued from page 6

system (arms), sensory system (eyes, ears), locomotion system (feet), command and data link (nervous system), source of prime power, and control console; examples of proposed remote handling machanisms for space applications, e.g. satellite maintenance.

Turbine Powered Transport Aircraft in USSR, D. J. RITCHIE. Paper No. 345A. Developments based on Soviet sources of information; background of Soviet civil aviation; characteristics of turbine engines; design features of transport aircraft; 3 main types of turbine engine fuels used; comparison with U. S. aviation; future of Soviet commercial aviation. 28 refs.

Axial Flow Compressor Noise Studies, J. M. TYLER, T. G. SOFRIN. Paper No. 345D. Basic processes for generation, transmission and radiation of noise in jet engine compressor are explored by Pratt & Whitney Aircraft; pressure field generated consists of spinning mode patterns; number of lobes in each pattern, and frequency of pressure fluctuations, gives speed at which pattern spins; critical pattern speed separates subsequent behavior of pattern into one of two different categories.

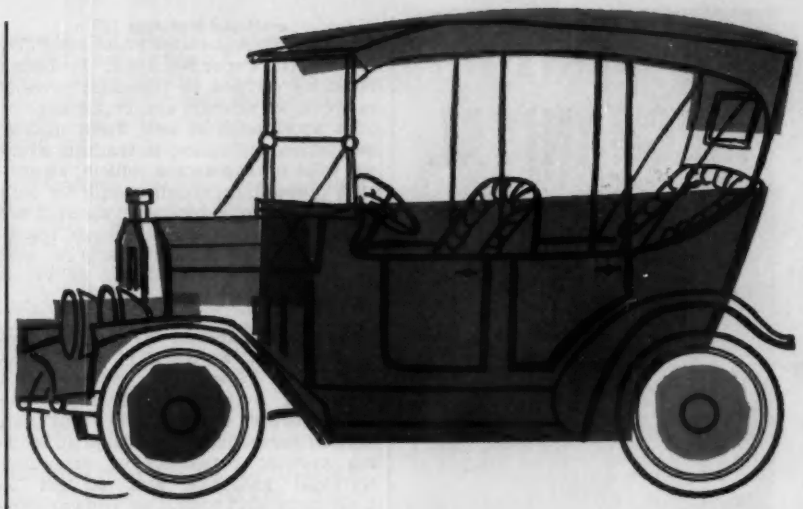
Integrated Low Thrust Solar Propulsion-Power Generation System for Communication Satellites, B. T. MACAULEY. Paper No. 346B. Development of Flux Trap device by Sunstrand Aviation which greatly reduces mirror accuracy required to achieve high propellant temperatures necessary for solar propulsion and electric power generation system; system application and mission studies; conceptual designs, feasibility studies and design solution considerations.

Application of Electrical Thrust Devices to Propulsion and Attitude Control of Space Vehicles, C. J. McDOLE. Paper No. 346C. Electrical thrust devices under investigation include MHD, electrothermal, and electrostatic engines, with distinctive variations possible in each type, which are explained; it is shown that different types of electrical thrust devices are required for different types of missions, showing need for simultaneous development of all types; examples of selected missions; review of research and development program, present and future.

Experimental Studies of Pulsed Plasma Pinch Space Engine, C. C. CAVALCONTE, I. GRANET, W. J. GUMAN. Paper No. 346D. Work at Republic Aviation to provide thrust for satellites in orbital flight and develop pulsed plasma pinch engine; thrust is variable, depending on pulse rate, propellant mass and energy per pulse; pinch effect principle; thrust estimate by calculation; optimization of performance to arrive at best electrode shape and charge capacitors efficiently; prototype engine XE-1 having 1 kw maximum rating, output of 0.01 lb thrust at 2 pulses/sec repetition rate.

Piloting Techniques — Changing

continued on page 130



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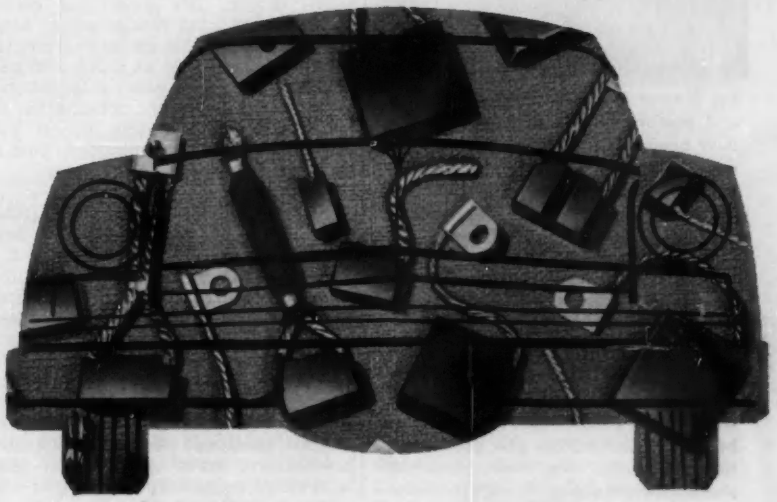

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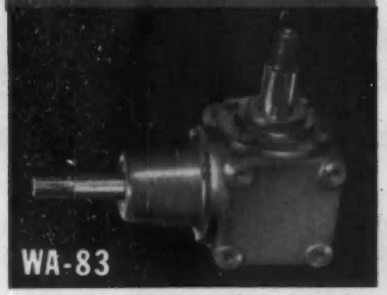

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For Hydraulic Power Transmission, See Wooster Division

continued from page 129

Scene and Its Associated Problems, P. W. HOWSON. Paper No. 348A. Problems faced by airlines in digesting present range of jet aircraft and importance of pilot acceptance of new flight instrumentation, difficulties in training average pilot for supersonic vehicle; significant operational requirements for safe introduction of subsonic jet aircraft are take-off monitor for all large transport-type aircraft, particularly jet, and acceptance and installation of visual approach system.

Autoflare Landing System for Jet Transport, R. K. SMYTH, E. W. VELANDER. Paper No. 348B. North American Aviation's system for use when weather conditions are less than normal minimums of instrument landing system; capability of extending terminal guidance and control to touchdown and rollout on runway providing landing in 0–0 conditions; use of information from system involves coupling of computer with automatic flight control system, and manual instrument landing where pilot assumes active role; terminal control synthesis procedures in flare computer design.

Integration of Gust Alleviators in Flight Control Systems, G. M. ANDREW, F. H. GARDNER. Paper No. 348C. Principles of gust alleviation; technique employs high response, servo driven, lift modifying control surfaces and wind flow sensor or accelerometer to provide signal representing gust velocity profile as input command signal to gust alleviator; integration in flight control system; schematics and block diagrams; system which integrates human pilot, autopilot, gust alleviator, and rigidity augmentor.

Significant Environmental Differences Between Powerplants for Aerospace and Underwater Missiles, J. F. BRADY. Paper No. 349A. Most differences can be traced to missile environments, i.e., media in which they operate, which dictate design and performance requirements; interactions as they affect propulsion system design are: density's effect on power requirements, on thrust producer, and on prime mover output; medium's effect on prime mover metallurgy, wave propagation losses and effect on powerplant design; other environmental considerations.

Turboelectric Power Generation for Space Vehicles, D. P. ROSS, J. E. TAYLOR. Paper No. 350A. Need for development of advanced thermoelectric powerplants and effect on design of turboelectric powerplants: cycle working fluids and energy sources; power conversion system and heat transfer equipment; conceptual design of 1 Mw nuclear potassium vapor power system using lithium cooled, fast reactor; use of 4 250-kw hermetically sealed rotating units containing turbine, alternators, and jet boosted centrifugal condensate pump.

Design Considerations & Development of Solar Space Power Test Facility, D. C. MILEY. Paper No. 350B. Review of state of art of solar space power systems and usefulness of solar test facility; basic requirements of latter are good weather conditions and high solar intensity, sun tracking platform, instrumentation, and weather protection, and cycling capability; General Electric facility, Phoenix, Ariz., built for ground testing and evaluation of solar space power systems, such as thermionic, thermoelectric, and thermomechanical systems, with or without energy storage.

Solar Thermionic Space Power Systems, R. E. HENDERSON, D. L. DRESSER. Paper No. 350C. Preliminary design for two solar thermionic systems is presented to establish potential capabilities of system, define critical design problems, and compare thermionic system with other power conversion systems; first mission is low-orbit earth satellite requiring up to 500 w continuous power, using vacuum diode; other mission is taken as Mars space probe utilizing vapor converter. 42 refs.

All Mechanical Servo Actuating Systems and Their Relation to Advanced Vehicle, D. GRUDIN, J. L. HALL. Paper No. 351A. Accurate position control device for powered actuation to position any desired element in response to command signal; its use as servo actuator in flight control system for power adapter, servo, transmission system, actuator, and portion of auto pilot system; source of secondary power is main engine; schematic of closed loop flight control system, controllable by pilot or autopilot; functions of basic elements.

Temperature — Response Diagram, A. S. LERMER. Paper No. 351B. Behavior of hydraulic flight-control systems exposed to high temperatures encountered by supersonic aircraft and effect on systems stability; temperature-response (T-R) diagram makes it possible to analyze such temperature effects; it contains rectangular locus of safe operating conditions, and may be used for determination of mechanical or thermal system equalizers which neutralize adverse temperatures influences; principle of T-R diagram.

New Techniques in Automatic Flight Control System Design, E. HARTOG, H. MOREINES. Paper No. 351C. Bendix Corp.'s approach to control system implementation in which analog nature of signals is preserved, but operations to be performed are digitally or pulse controlled; analog data processing involves storage elements, adaptive gain changing, and solid state drives for high performance electric motor actuators.

Acceleration (g) and Visual Performance, W. J. WHITE. Paper No. 352A. Effects of acceleration on vision; subjective reports of gross effects of acceleration, stimulus variables upon

which they depend, and their cardiovascular correlates; results of use of objective measures of effects of acceleration on vision include, experimental measures of brightness discrimination, visual acuity, flicker discrimination and measurement of visual fields and oculomotor reflexes. 52 refs.

Andrometry: Practical Application of Coordinate Anthropometry in Weapon System Design, J. W. CHAFFEE. Paper No. 352B. Photogrammetric procedure, called andrometry, of photographically measuring human body and recording x, y, and z coordinates of these measurements; two cameras are set up so their optical axes intersect at 90 deg and spatial location and dimensions of any object which appear in both cameras accurately determined; use of andrometric study in design of escape capsule; accuracy of technique.

Selected Methods for Atmosphere Control in Manned Space Flights, M. G. Del DUCA, A. D. BABINSKY, F. D. MIRALDI. Paper No. 352C. Problem of providing breathing oxygen, and removing carbon dioxide from cabin atmosphere; tabulation of promising gaseous regenerative systems, and total weight, volume, and power requirements per man; regeneration of O_2 from CO_2 by hydrogen reduction and electrolysis; regeneration of O_2 from CO_2 by photosynthetic methods.

Sonic Proof Testing B-58 Weapons System, J. R. BALLENTINE. Paper No. 353A. Details of 10-hr maximum afterburner power ground sonic fatigue test, conducted at Convair-Fort Worth designed to show expected service life of structure and systems when exposed to noise, means for predicting maintenance task on future operational B-58 airplanes, and design improvements to reduce sonic fatigue problems; types of failures; applications of correlated data and empirical equations for preliminary design, final design and redesign purposes; recommendations.

Harmonic Analysis of Bending Moments on Turbine Blades Due to Irregular Temperature Distribution at Turbine Inlet, R. D. STOTTLE. Paper No. 353C. Method for evaluating cyclic pattern of bending moments on turbine blades; only information needed is temperature distribution at turbine inlet; mathematics involved in numerical evaluation of harmonic coefficients is sufficiently accurate for engineering purposes up to harmonic which is one half number of probes used in temperature traverse.

Thermal Radiation as High Temperature Energy Transport Mechanism Within Solids, H. P. KIRCHNER, F. A. VASSALLO. Paper No. 354A. Evaluation of radiative transport as means for removing heat from rocket nozzle walls; mechanisms contributing to ordinary thermal conductivity of metals and dielectrics and factors limiting conductivity; radiative transport and ordinary conductivity characteristics of solids are compared; analysis of rocket nozzle design illustrating advantages of using radiative transport within solids to extract heat from nozzle wall.

Dimensional Stability Together with Ablation, F. A. VASSALLO. Paper No. 354B. Body composed of porous matrix of high melting point such as expansion nozzles of rocket motors which is initially saturated with relatively low temperature ablating material is considered; this combines stability of efficient heat sink and heat dissipating ability of ablation and transpiration cooling processes; analysis and description of processes; tabulation of matrix and ablative materials.

Ceramic Heat Shields for Glide Re-Entry Vehicles, R. M. DAVIS. Paper No. 354C. Mercury man-in-space program involves ballistic type re-entry vehicle utilizing ablative and heat sink materials in its primary heat shield; basic reasons for trend toward lifting type re-entry, heat shield problems of these vehicles, role that ceramics may play in lifting vehicle radiative shields, and test on two ceramic materials.

Jet Lift VTO — Short S. C. 1, H. G. CONWAY. Paper No. 356A. Research aircraft making use of jet lift, developed by Short Brothers & Harland Ltd.; features of S.C. 1 type system which enable it to carry out safely transitions from hovering to conventional flight and back to hovering; Rolls Royce RB.108 lift engine has thrust weight ratio of 10:1; engine tilt, control system, and other details.

Space Age Ground Support. A. B. BILLET. Paper No. S302. Illustrates GSE needed in missile and near-future space applications — where requirements have accelerated rapidly. Details results of a study of problems met in long-term storage of GSE, and mentions briefly possible future requirements for all kinds of GSE.

GROUND VEHICLES

The Effect of Motor Racing on Automotive Advances. H. E. PRINGHAM. Paper No. S301. Discusses possible contributions to passenger car design from study of race car designs and experiences . . . especially as regards suspension systems. Claims that contributions of racing to car design have been important over the years. "There will always be proof that without competition there is no real progress."

MARINE & INDUSTRIAL APPLICATIONS

Marine and Industrial Uses of Proteus and Olympus Engines, B. H. SLATTER. Paper No. 347A. Significant characteristics of Bristol Siddeley Proteus propeller turbine and Olympus jet engine; factor which justifies use of aero engines in marine field is low weight and bulk; full range of in-

continued on page 132

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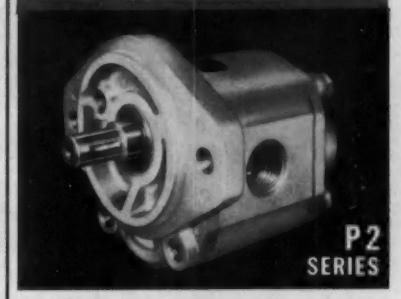

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For Mechanical Power Transmission, See Warner Automotive Division

continued from page 131

dustrial uses is more difficult to define, but most beneficial applications are likely to be those in which utilization is low; examples of applications.

Industrial Power Requirements and Aircraft Gas Turbine Engine, W. J. CLOSS. Paper No. 347B. Use of aircraft turbine as prime mover in heavy industry; power package consisting of Pratt & Whitney modified J-57 engine, adapted to burn natural gas, and Cooper-Bessemer heavy duty free power turbine to convert thrust of J-57 into 10,500 shp as continuous rating; Cooper-Bessemer gas line compressor, automatic and remote control system; experience of Columbia Gulf Transmission Co., Houston, Tex.; advantages of turbine for peak electric power shaving.

One Pound/Horsepower — New Weight Standard for Ground Power, K. A. AUSTIN. Paper No. 347C. It appears that discipline evolved for aircraft turbine design is directly applicable to marine and industrial power plants; definition of service ratings for intermittent duty, continuous running, and heavy duty; problem areas are vehicle transmissions, dynamic braking capability, salt water and sand ingestion; acceptable overhaul interval of 7500 hr or better can be expected for engines of less than 1-lb/hp specific weight; example of 2000-hp power package.

Impact on Logistics of Hydrofoil Amphibians, L. S. VOTRE, F. STORA. Paper No. 355A. Logistics of amphibious assault divide into loading and unloading, water, and land movement phases; new hydrofoil equipped amphibians have greatest significance in water transportation; comparison between four different amphibians and hydrofoil versions shows that latter can handle 4–6 times cargo of other amphibians; example of 36 ft aluminum vehicle by Lycoming Div. of AVCO Corp.; it weighs fully loaded 31,500 lb, and is powered by T53 gas turbine.

Structural Design for Safety in High Speed Hydrofoil Ships, R. G. MERRITT. Paper No. 355B. Features of hydrofoil platform to carry desired payload given distance at desired speed, and necessary safety and protection for crew and equipment; aspects of structural design of hydrofoil ship which affect integrity and safety; how increase in hull deadrise will result in decrease in hull pressure loadings during landing impact; increase in hull deadrise will not affect hull righting stability; load criteria, fatigue, and structural stiffness.

Characteristics of U.S. Maritime Administration Hydrofoil Test Vehicle, G. J. WENNAGEL. Paper No. 355C. Design of vehicle by Dynamic Developments, Inc. and Grumman Aircraft, capable of operating with 2 different hydrofoil systems; first embodies subcavitating hydrofoils for speeds up to 60 knots; second attains speeds to 80 knots; power for foil borne operation is provided by GE MS-240 gas turbine engine, power for displacement operation by GE YT-58-2 engine; developmental structural and hydro-dynamic testing; tests in Grumman Whirling Tank Facility.

Chemically Fueled Propulsion System for Deep Submergence, H. L. HOWELL. Paper No. 349C. Energy sources for propelling smaller undersea devices fall into pre-stored systems in which unit is "wound-up" prior to launch, and latent energy systems in which chemical energy is released through changes in molecular structure; use of rod crank type reciprocating engine, and exhaust gas pumping as method of extending depth capability of thermal engine to several thousand feet.

Nuclear Submarine Habitability, E. A. RAMSKILL. Paper No. 352D. Program and approach used by U. S. Naval Research Laboratory to identify various materials present in submarine space, determine concentration of materials, compare toxicity of materials with concentrations present, and to determine their source and control their concentration; methods used.

MATERIALS

Glue Line — Why, How, and When.

continued on page 134

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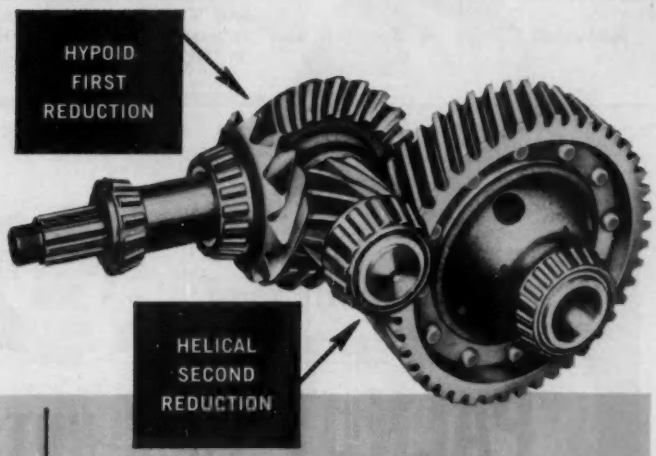

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continued from page 132

I. E. POSTON, K. D. DOWNING, K. J. MACK. Paper No. 330A. In case of adhesive bonding, glue line is defined as thin line or film of adhesive between two parts bonded together; advantages of modified epoxy resin structural adhesives; new materials developments are fast reacting epoxy resins and fast reacting curing agents; outline of general parameters for suitable adhesive in automotive metal-to-metal bonding applications.

Radiation Effects on Materials and Equipment, M. J. OESTMANN, J. F. KIRCHER. Paper No. 339B. Study at Battelle Memorial Inst. on permanent radiation effects of materials; summary of effects on metals tabulated; effects of neutron irradiation on tensile and impact properties and on hardness of some metals; inorganic materials, elastomers, plastics, and organic fluids; seals and sealants, and electrical and electronic components. 21 refs.

Some Stress Rupture Properties of Columbium, Molybdenum, Tantalum, and Tungsten Metals and Alloys Between 2400–5000 F, A. DONLEVY, J. K. Y. HUM. Paper No. 354D. Paper shows how electron beam heating can be used as heat source in stress rupture testing of refractory metals and their alloys; temperatures from 2400 F to above melting points can easily be obtained; principle of electron beam heating based on principles utilized in X-ray tubes; results for each set of alloys are graphically illustrated and tabulated.

PRODUCTION

Automatic Tape-Programmed Universal Checkout System, L. V. BJONG. Paper No. 331D. Concept for automatic testing and application of Air Force AN/GJQ-9 Checkout Sequence Programming Set, developed by Bendix Corp. to test complex missile system; functions and capabilities; tape reader is actuating element of program control; printer is controlled by semiconductor logic circuitry on printed cards; programming set is capable of selecting 200 test points for measurement and 100 channels of stimuli control for systems test; block diagrams and tables.

Hobbing Versus Gear Design, M. E. SAMUELSON. Paper No. 333C. Hobbing and its influence on gear design; factors which designer should consider.

High Energy Forming — New Manufacturing Techniques, J. P. ORR. Paper No. 340A. At Ryan Aeronautical Co. explosive forming is employed in aircraft and missile fabrication; abilities and limitations of materials used for explosive forming dies; kirksite, ductile iron, and concrete with epoxy face; use of explosive forming in manufacture of radar reflectors and solar concentrators; forming at elevated temperatures; techniques used to form missile bulkheads and unusual shapes; advantages.

Shearforming 7075 Aluminum, C. E. HOWLE, F. JACOBS. Paper No. 340B. Cost reduction program on 7075 Al alloy part machined from 36 lb forging at Temco Missile & Electronics Co., led to shear-forming chipless machining process; equipment used was Cincinnati 24 × 24 in. 2-roll Hydrospin Machine and Lodge & Shipley, single-roll, 40 × 72 in. Floturn Machine; process description; effect on material properties; 7075 Al alloy can be shearformed if attention is given to process variables such as machine setup, tool ring profile design and blank design.

Distortion Control During Heat Treatment of Aircraft and Missile Components, A. L. KITCHIN, H. MANSFIELD. Paper No. 340C. Nature and causes of heat treat distortion, in simple metallurgical terms; distortion prevention by restraint, by reducing temperature gradients, by reducing residual stresses prior to heat treatment, by controlling case distribution, by design, and by modifying manufacturing processes; distortion correction by machining or grinding, by compensating dimensions before

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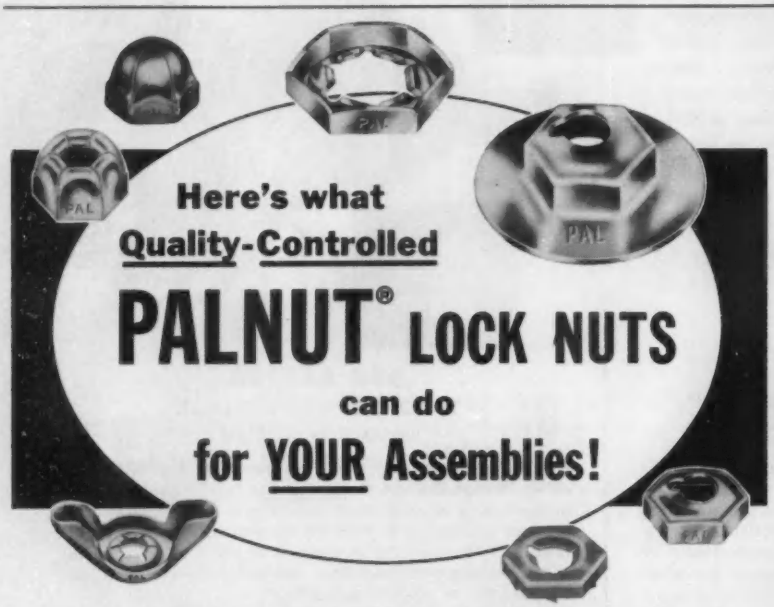

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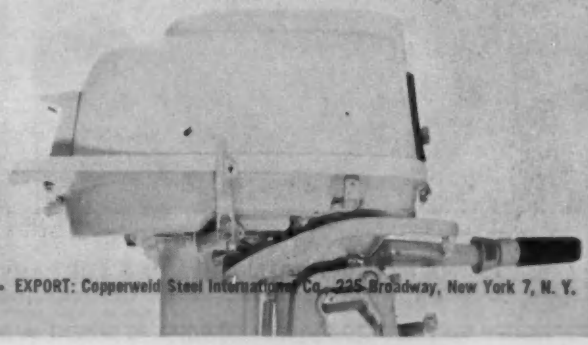

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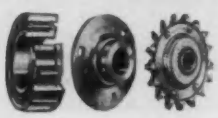

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

continued from page 134

heat treatment, and by straightening to finished dimensions.

Welding and Brazing of Refractory Metals, G. M. SLAUGHTER. Paper No. 340E. Considerations confronting fabricator of components of tungsten, tantalum, molybdenum, and columbium as well as beryllium in view of its importance as structural material in nuclear and space applications, compilation of melting points; transition temperature; reactivity with impurities; recrystallization of parent material; intermetallic formation and thermal expansion differences in brazing; typical applications. 20 refs.

Fabrication of High Thrust Lightweight Jet Engines, S. WEISS, D. E. HACKER. Paper No. 340F. Approach to fabricating sheet materials for jet engines; nominal chemical composition of major alloys used in components of various engine models and summary of room and elevated temperature mechanical properties of parent and welded material; tungsten inert arc welding is predominantly used in fabricating engine components; factors to consider in joint configuration; welding technique for defect free repairs.

Hot Machining of High Temperature Alloys Can Increase Production, J. L. WENNBERG, C. L. MEHL, E. J. KRABACHER. Paper No. 340J. Cincinnati Milling Machine Co. studies to determine effect of workpiece temperature on basic cutting parameters, tool forces, calculated shear strength of material, and tool-chip interface temperature; machinability tests for milling, turning and drilling various workpiece materials; heating methods include furnace heating, resistance, flame, radiant, induction, RF resistance, through-tool RF resistance heating and arc heating.

Small Hole Gun Drilling of Superalloys, D. A. STEWART. Paper No. 340K. Gun drilling as method of producing holes of less than ¼ in. diam. to depths of up to 6 in. investigated by Machinability Unit of General Electric Co.; 3 nickel base alloys, U-500, U-700, and DCM were tested; test method gun drilled holes 6 in. in length; holes can be drilled in superalloys to diameter as small as 0.093 in.; holes of 12 in. length with 0.125 diam. were drilled, but presented problems; finishes of average of 15 μ in. can be consistently obtained.

Productioneering in Aerospace Age Planning — Fundamental Technique, T. HECHLER, Jr. Paper No. 342A. Production problem in aerospace industry and work planning system which must function as working tool of scientist, engineer, tool planner, or production control man; system should provide for planning from ground up,

continued on page 139

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Manufacturers and users of equipment requiring hose assemblies can depend on Stratoflex flexible hose and hose fittings to reduce downtime through availability, thereby holding maintenance costs to a minimum. Designed for diesel, automotive, general industrial and commercial applications, Stratoflex hose and fittings have the proven durability that is necessary for dependable service. Stratoflex hose and fittings are available in a wide variety of sizes and types to meet every requirement. Shown above are typical installations where Stratoflex hose and fittings are giving economical, dependable service.

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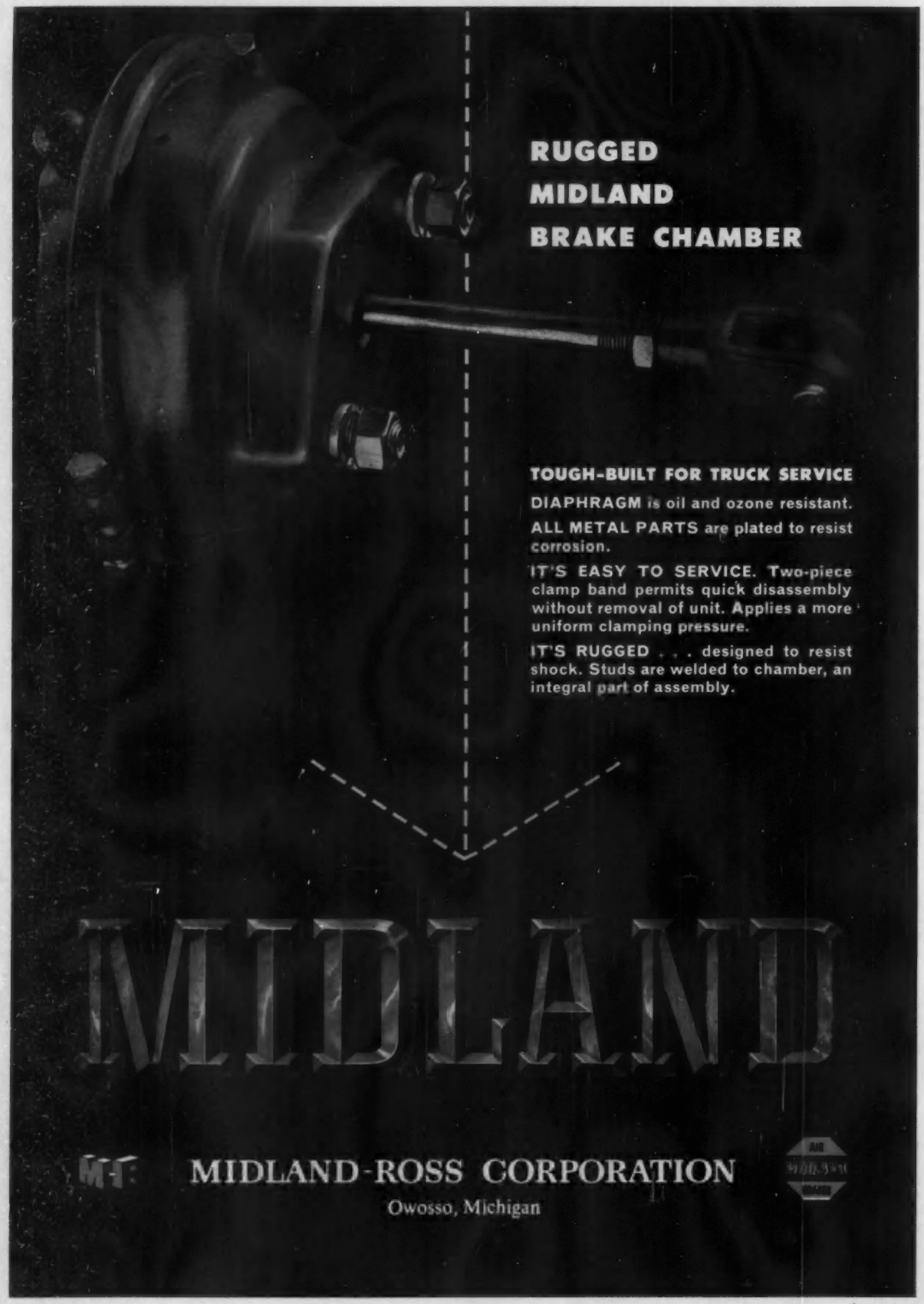
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continued from page 137

provide for periodic progressing, or measuring of results; use of "Gantt Chart" is advocated which displays work planned, and progress against plan in same time-reference.

Industrial Engineering Before Act, J. F. RINGO. Paper No. 342B. Industrial engineering thinking or "value engineering thinking" should be made on basis of benefit (or value) to entire organization; to be totally beneficial, value engineering must be applied throughout organization, in its indirect activities as well as its product activities; suggestions made how this can be accomplished to expedite production program.

Martin Company's Project Management Method, K. P. BOWEN. Paper No. 342C. New projects are handled by organizing team consisting of project, program, and project engineer; functional divisions then select managers to round out team; group prepares outline of work scope to develop schedule flow charts for manufacturing sequence and control points which in turn is used to prepare cost estimate; functions performed by team to develop most efficient short flow, low cost schedules are outlined.

Implications of Producing Aerospace Weapons at Planned Low Rates, L. R. KOEPNICK. Paper No. 342D. Because of nature of aerospace systems it is imperative that effective production engineering, planning, and tooling be used from outset, and that production processes and procedures insure interchangeability and repeatability of performance; appendix contains excerpt from AMC Aeronautical Systems Center Organization and Functions Chart Book covering subjects of ASC's program management philosophy and advanced systems operations; problems which must be faced.

Meeting Productioneering Challenge, P. T. SMITH. Paper No. 342E. Approach taken by Aero-Space Div., Boeing Airplane Co., toward organization for program management; several significant trends in manufacturing operations are discussed and specific examples of operational techniques which have increased capabilities given.

Method for Critiquing Designs and Predicting Reliability in Advance of Hardware Availability, R. BUSSIERE. Paper No. 343A. Design reliability can be predicted, if it is possible to infer approximations to two statistical distributions: probability density function of strength, and of maximum stress, that component will experience; Monte-Carlo method for estimating stress probability density function programmed for IBM 704 computer, on basis of known design, manufacturing, and operational parameters; examples of premature aircraft turbine blade failures; critique of shear coupling design.

Reliable Spacecraft Designs, I. DOSHAY. Paper No. 343B. Along with initial program, analysis must be made of entire vehicle design requirements to establish components and environments; reliability goals and allocations of subsystem goals; to illustrate technique for estimating reliability, preliminary estimate for proposed spacecraft power supply subsystem is presented; reliability emphasis in design study using statistical methods to devise economical configuration of redundant design; design review method; reliability during development; subsystem qualification testing.

Categorization of Human Errors in Rocket Engine Testing, I. B. BLANK, G. S. MILLER, Jr. Paper No. 343C. Study made to classify human-initiated failures in testing of rocket engines for Liquid Rocket Plant, Aerojet-General Corp; from computer printout of all human errors for reporting period Jan. through Dec. 31 1959, those failures indicated as having occurred in test procedure were reserved for investigation; outline of human errors formed for each stage of installation, use, settings and wiring, fueling, and repairs; conclusions and recommendations.

Introduction to Theory of Reliability, R. P. HAVILAND. Paper No. 343D. Theory which explains occurrence of failures in objects, and permits calculation of time at which such failure occurs; starting point is observation by Peirce, that "strength of object is strength of its largest flaw"; equations which permit engineering calculations of life, therefore, of reliability.

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New Members Qualified

These applicants qualified for admission to the Society between May 22, 1961 and June 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: Graham Scott Montgomery (J).

Atlanta Section: B. Leo Wilson (A).

Buffalo Section: Cecil E. Angell (M), Robert James Donaldson (A), Lawrence Jack McLaughlin (M), James Francis Sweet (J), Robert E. Weider (M).

Central Illinois Section: William Donaldson Brandon (J), Robert Edward Emmert (A), Dewey Charles Fitch (J), Lowell Ernest Johnson (J), Dale Kempf (J), James Phillip King (J), William Porter Sly (J).

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Chicago Section: William Dennis Doyle (J), Howard Edward Dwan (J), Donald George Hallahan (J), Paul Hanebuth (M), Jimmie Lee Hasten (J), Martin T. Laffey (M), Richard Jacob Schweitzer, Jr. (J), Stanley Walter Turner (J).

Cincinnati Section: Charles Taylor Hamilton (M), Carl Walter Weiland (M).

Cleveland Section: Robert J. Buettner (M), Glenn Wilbur Carter (J), Lee D. Keefer (J).

Colorado Group: Robert William Miller (J), Richard A. Sharp (J).

Dayton Section: John Henry Apel (M), Ronald Walter Bennett (J), John R. English (M), Erwin Carl Meissner (J).

Detroit Section: Robert L. Adams (M), Randall Edward Beinke (M), Michael Anthony Bowen (J), Robert Edward Brackett (M), William Frederick R. Briscoe (M), Emmett Vincent Brogan (M), Edmund John Brune (J), James B. Carson (M), T. A. Chapekis (M), Harry Henderson Chapman, Jr. (A), Jean Joel Cordier (J), Howard John Daenzer (J), Edgar Siling Eckel (A), William John Flower (J), Fred Easa Ghannam (J), Donald Wayne Gorrell (M), Teddy Joseph Hajjar (J), John Alton Hall (J), David Peter Hass (M), William Charles Herman (J), Donald D. Hurd (M), Richard Thomas Jensen (M), Norman John Kaarre (J), Nicholas Kenjoski (M), Richard F. Kienle (M), Gene Louis Leithauser (M), Robert Charles Liem (M), Charles Kenn Litzenberger (J), Ellis R. Lovell (M), William John Martin, II (M), Frederick Henry McKaig (J), Gerald W. Messenger (M), Theodore W. Miller, Jr. (M), Leonardo Monacelli (J), William Louis Nagy (A), Edwin Wallace Norman (A), Robert R. Owen (M), Douglas Miles Patterson (J), Richard John Pattison (A), Clement James Roberts (J), John D. Rogowski (M), John Edward Rossbach (M), Leo Scalakin (M), Robert E. Schrock (M), John Edward Sheffield (A), William H. Sink (M), Bert Kenneth Sisson (J), Raymond Paul Smock (J), James I. Stalker (M), James A. Stumph (J), Donald Robert Taylor (A), Leo Robert Toomajian, Jr. (J), Joseph Frank Waughn (J), Norman Valentine Wiatr (J).

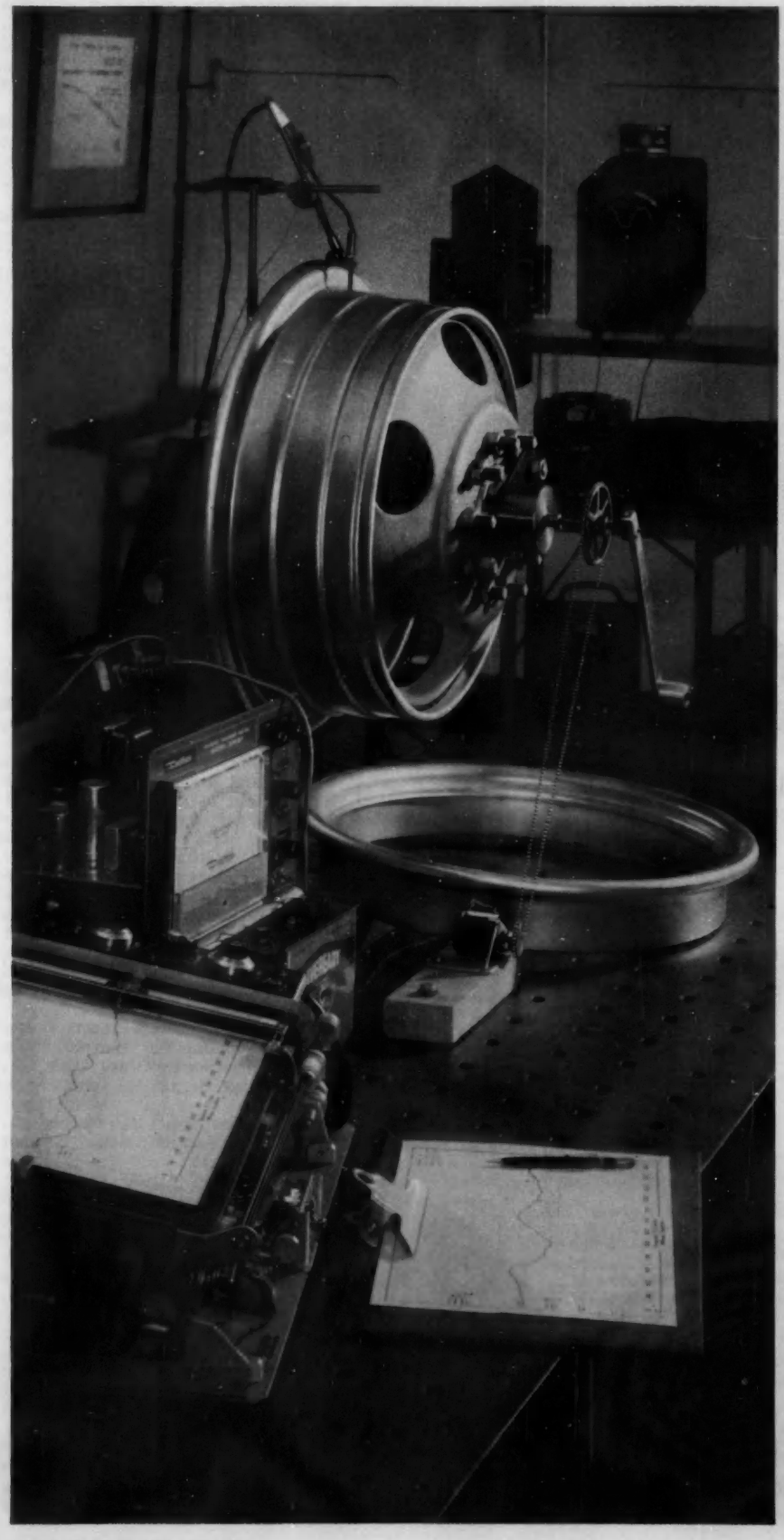
Fort Wayne Section: Jan M. Smith (J).

Hawaii Section: Robert Stewart Baxter (A), Lee B. Porter (A).

Indiana Section: Frederick Sylvester Clevenger (J), Everad A. Comstock (M), John Henry Evans (J), Henry A. Hawken (M), Donald Lee Hollands (J), Michael Francis King (J), David Ross Thompson (J).

Kansas City Section: Don Frederick Sole (A).

continued on page 142



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K H

Payloader H-70—photo courtesy The Frank G. Hough Co.

R/M sintered friction development use-proven in over 6000 Payloaders

The Hough-built "PAYLOMATIC" P-600 full power-shift transmission utilizes a wet-friction application jointly developed by The Frank G. Hough Co., Libertyville, Ill., and Raybestos-Manhattan.

No friction failures

Project engineer Harry Wilson says: "We have over 6000 units in the field. There hasn't been a friction failure in the lot. The design we developed with R/M's cooperation has been use-proven. We're well satisfied with R/M's ability to help design and then deliver a superior friction material at a competitive price."

Several types of materials were tested in R/M laboratories and then on Payloader tractor shovels. Sintered bronze was the material chosen for the friction plates. Plate speeds range from 1370 to 6140 rpm; gross plate pressure to 180 psi.

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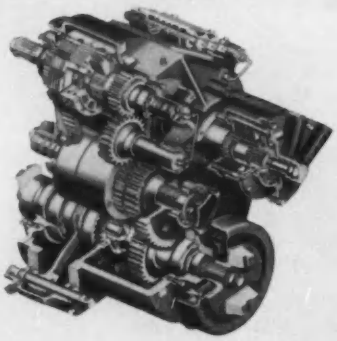

"PAYLOMATIC" full power-shift transmission; 3-speed, fully reversing, constant mesh, countershaft type with balanced, rotating, hydraulic clutches continuously pressure-filled, cooled and lubricated.

This sintered friction plate, OD 5 ¾ in., is used in an oil-immersed application in "PAYLOMATIC" transmissions. The number of plates and the ratios vary between the models to meet torque requirements.

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New Members Qualified

continued from page 140

Metropolitan Section: Eric Swire Bates (M), A. John Cummings (A), Ray John DeChaine (J), John Anthony Diaks (J), William Charles Hollopeter (M), Edward Clark Kenyon (M), Eitaro Kurihara (M), John Carlisle Maclay (J), Berj Missak Manoukian (J), Halsey Paul Quinn (M), Jeremy Fisher Stead (J), Conde Blaine Walker (A).

Mid-Continent Section: William Conner Woerner (J).

Mid-Michigan Section: Frank W. Huxtable (M), James Russell Lovell (J), Don A. Miller (A), Donald Earl Mueller (J), Herbert Joseph Stange (J), Donald K. Steiner (M).

Milwaukee Section: Donald George Bethke (J), Paul William Freedy (J), Richard Edward Lietz (J) Karl Edward Richter (J), Richard W. Swanborg (A).

Montreal Section: Fernand A. Belanger (J), Christopher T. Newton (A), Lionel L. Reeves (M), Charles Henry Turner (J).

New England Section: John A. Chafey (A), William E. Davis (M), Winfred Valma Walker (A).

Northern California Section: Kenneth Leroy Bergman (J), Arthur James Giles (A), Ronald Eugene Marsolek (J), James Richard Mathers (J), Andrew K. Nielsen (M), Gerald Lyle Shreve (J), John Patrick Sloan (A), Wayne E. Thompson (M), John J. Weaver (M), Gary Eugene Wilson (J).

Ontario Section: Oliver Robert Bosso, Jr. (M), Thomas De Boer (J), Roy Overton (A), Charles Grant Slinn (J), Steve Vdoviak, Jr. (J).

Oregon Section: Bruce Jan Bekins (A).
Philadelphia Section: John Howard Weise, Jr. (A).

Pittsburgh Section: Nicholas Joseph Scheid (J).

St. Louis Section: George R. Baumgartner (J), Harold Edward McCormick (J), Wayne LeRoy Page (J), Reginald Douglas Waite (J).

San Diego Section: Charles William Newhall (M).

South Texas Section: James Loyd Hill (J), Richard Orville Pearson (J).

Southern California Section: Sang Ho Choe (J), Lawrence James De Young (J), Scott Fenn (A), Thomas Lee

Fidler (J), John Edmund Harrell (J), A. Jack La Torre (M), Evald Erik Lindgren (M), William Douglas McBride (J), Jim Lee Mosman (J), Robert N. Turk (J), John Edwin Winkler (J).

Southern New England Section: Paul Edmund DesRosiers (J), Benjamin Lewis Hochman (J), Donald R. Muzyka (J), Alfred Knowles Wood (M).

Spokane-Intermountain Section: Clarence S. Jolley (A).

Syracuse Section: William Joseph Beall (J), C. Richard McCray (M).

Texas Section: John Czuwala (M), Harold Ivan Knight (M), Donald J. Weber (A).

Texas Gulf Coast Section: R. Sterling Barnett (A), H. D. Graf, Jr. (A).

Washington Section: Donald Bruce Talmage (M), Richard P. White (J).

Western Michigan Section: Jerome Kermit Gensler (M).

Williamsport Group: Richard W. Fullerton (J).

Outside Section Territory: John Craton Armold (A), Claud Randall Comer (J), Norman F. Lemmon (J), Malcolm Asbury Stephens (M), Lt. Charles H. Ulrich (J), Herman I. Wilson (M).

Foreign: Eduardo Ramon Abril (M), Argentina; Joginoer N. Anand (J), India; Enrique Antonio D'Acosta (A), Mexico; John Giles (J), England; Hector Melo (M), Mexico; Arvin Ramchandra Savkoor (J), India; Captain Gurbux Singh (M), India.

Applications Received

The applications for membership received between May 22, 1961 and June 22, 1961 are listed below.

Alberta Group: Victor Lawrence Humaniuk

Baltimore Section: Wesley Homer Fesler, George E. Maffey, Jr.

Central Illinois Section: Peter Edwin Matuschak

Chicago Section: Edward N. Dickson, Wendell S. Linnell, Joseph John Morocco, Stephen H. Paul, Donald Irving Reed, W. Van F. Schroeder, Lester C. Tiscornia

Cincinnati Section: Keith E. Terry

Cleveland Section: James Reymond Barrett, Howell Keith Brewer, Cnas. F. Emish, William Patrick Kelley, Peter James Koole, Andrew J. Nenadal, D. Brian Wheeler

Colorado Section: Robert Allen Shumate

Dayton Section: David E. Bearint, James Alan Finfrock, George Gill Maxwell, Robert James Simons

Detroit Section: Phillip Hawley Avery, T. Michael Brogan, Albert Cimarosti, Leonard George Cyr., Jr., Thomas Roger Danielson, Duane Dennis Eichstaedt, Robert William Gray, Carl Victor Hajek, Lowell Atwood Hibbits, Ralph Kenneth Hillquist, Carl John Koskinen, Arthur Lamont, Lawrence Wallace Lang, Carl J. Lutkehaus, Jr., William Alfred Mueller, Louis Norbert Ollier, Adolph E. Woltanski

Hawaii Section: Seichi Kato, George Toshiaki Nagano

Indiana Section: Delbert F. Case, James E. Knott, Lawrence Robert Myers, Ronald Dewese Waugh

Kansas City Section: Gerald E. Gaylord, Hilera Marcus Hardy, Alfred C. Metz, Jr., Hugh Irvin Myers

Metropolitan Section: Frank Campanile, Einar K. Christensen, David Baxter Gordon, Charles Teh-ching Hsu, Ira S. Nigen, Michael Joseph Ostrelich, Donald E. Schick, Wallace B. Spielman, Jeffery Allan Waldmann

Mid-Continent Section: Ellis Garlington, Jr., Wilbur S. Light

Mid-Michigan Section: Joseph K. Decker, Keith Dale Harris

Milwaukee Section: Donald John Huhn, William R. Kilponen, Thomas J. Krause, Malcolm T. Stamper, John Paul Stoltenberg

Mohawk-Hudson Section: James LeRoy Knowles, Donald A. Seal

Montreal Section: David Wilfred Holland Godfrey, Harry Alfred Hallewell, Donat A. Martinoli, Fernand Tetreault

New England Section: William Robert Harrison, Alphage Louis LeVasseur

Northern California Section: Donald Curtis Patston, Yutaka Yamamoto

Northwest Section: William K. Burke,

continued on page 144

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Proper selection of the best adhesive for a given application can reduce your costs and improve your product. There is no known all-purpose adhesive.

To choose the best bonding agent, you must assign degrees of importance to the following five factors:

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How much importance to each point? That is where Raybestos-Manhattan's years of experience can prove profitable for you. Almost all the Ray-Bond adhesives available today can be effectively modified to meet your particular bonding requirements. We would welcome the opportunity to work directly with you to select or develop the type or types of adhesives best for your purposes. A Raybestos engineer can call at your convenience. Won't you let us hear from you soon.

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Powered by Continental Model 10470-E
260-hp Fuel Injection Engine

Continental Motors Corporation
AIRCRAFT ENGINE DIVISION . . . MUSKEGON, MICHIGAN

Applications Received

continued from page 143

Ivan Gordon Myers, Jr., William Grant Nelson

Ontario Section: Gordon G. Furey, Harold William Jackman, Andrew Lenkei, Lawrie Ray Nichol, Terence Smith

Philadelphia Section: George R. Harrington, George W. Leck, III, Robert Van Fleet Tompkins

Pittsburgh Section: John Regis Dougherty, Richard W. Simon, Herbert E. Stiles

St. Louis Section: Richard Eugene Kuster

San Diego Section: Donald George McDonell, Brian Boru Spillane

Southern California Section: Isaac Garrott, Jr., Richard Elmer Horner, Rodger Alan Jump, Jackson Ramsey McGowen, Richard J. Thorman

Southern New England Section: Paul John Fitzgerald, Charles F. Shelton, Jr.

Spokane-Intermoutain Section: Colin John Sandwith

Syracuse Section: William Ronald Forbes

Texas Section: Jimmy Hill Blake

Texas Gulf Coast Section: Don Michael Batey, Robert Anthony Krenowicz

Twin City Section: Horace Brewster Atwater, James Edwin Guisinger, James Norbert Johnson, Harlan D. Kuester, Wayne A. Rigg

Washington Section: Dave K. Anand, Charles James Gauthier, Richard B. Teiper

Western Michigan Section: Michael James Dempsey

Outside Section Territory: David Edward Cross, Ronald William Glasman, Hilton W. Mitchell, Richard Christian Navarin, Martin Joseph Paul, David Jackson Payne, Roland P. Rebhorn, Gabriel E. Stern, Herbert D. Sullivan, Charles G. Termont

Foreign: Alexander V. Alexander, India; Carlo Felice Bona, Italy; Carlo Donatelli, Italy; Sergio Farina, Italy; Wilfrid Oswell Garner, Australia; Robert John Gladwell, England; Daniel Spepala Seneviratne Jayatillake, Ceylon; Enrique Jose Lorenzo, Argentina; Richard Cass Morris, England; Shiv Narayan Shrivastav, India; Gabriel Tornell, Mexico

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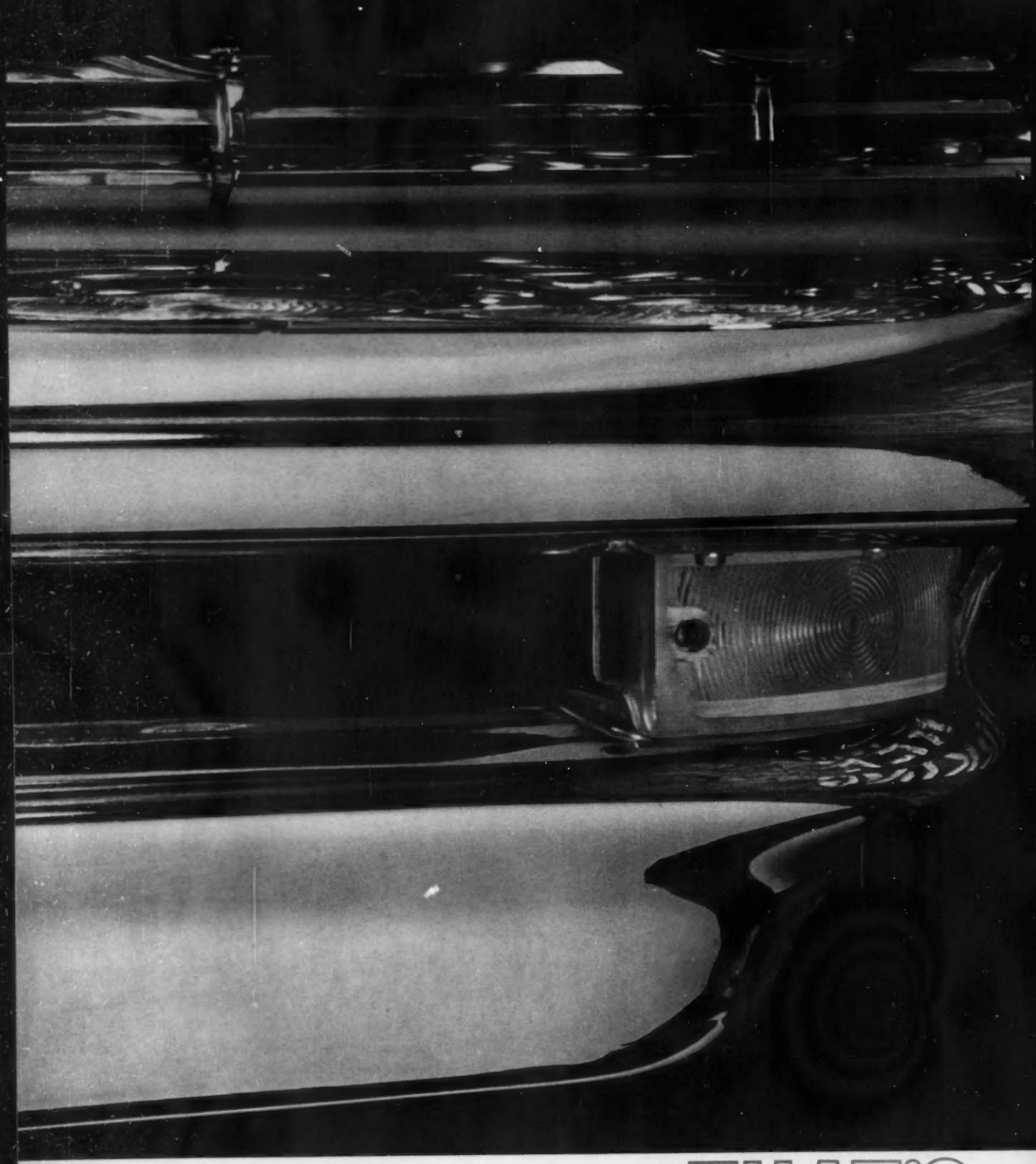
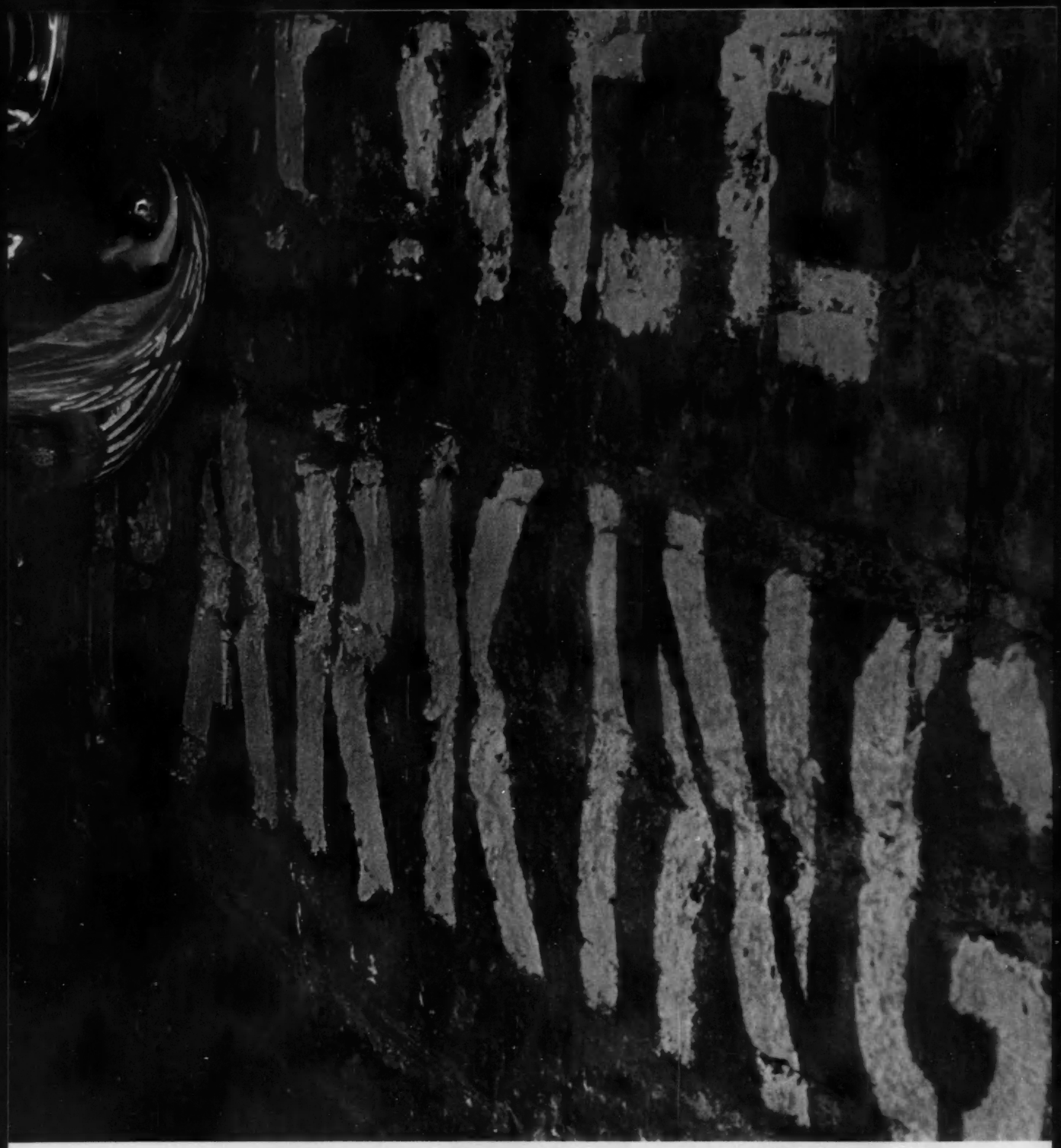


DENT RESISTANCE... THAT'S THE BEAUTY OF STEEL



Car buyers want steel bumpers for their greater strength and the way they take parking bumps and impacts without denting or dimpling. Automotive designers want the freedom of design that comes with steel's ability to take deeper draws and more intricate forming than lighter metals such as aluminum. Production engineers want steel's superior fabricating qualities and lower polishing costs. They *all* want steel's extra margin of safety.

When it comes to bumpers (or other parts that require strength, design flexibility and low manufacturing costs), steel is stronger—looks better longer. Great Lakes Steel Corporation, Detroit 29, Michigan.

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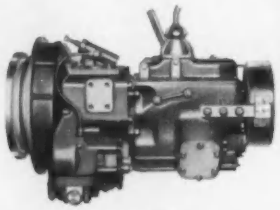

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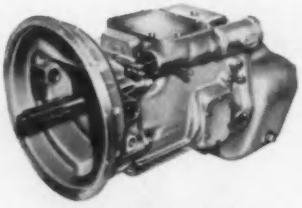
torque converter-clutch-transmission packages



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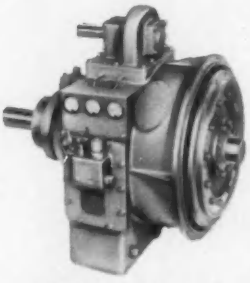
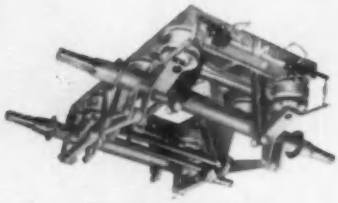
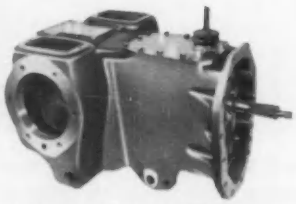


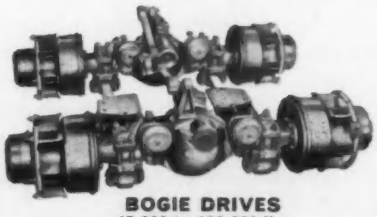
TORQUE CONVERTERS
9" to 28" diameters



AIR SUSPENSIONS
single, tandem, and spreads;
up to 36,000 lbs



AGRICULTURAL UNITS
transmissions, axles, PTO's



BOGIE DRIVES
45,000 to 180,000 lbs

CLARK EQUIPMENT

TransVerter is a trademark of
CLARK EQUIPMENT COMPANY
AUTOMOTIVE DIVISION
Buchanan 5, Michigan

THIS OIL RING PROMOTES YOUR SHOP'S REPUTATION

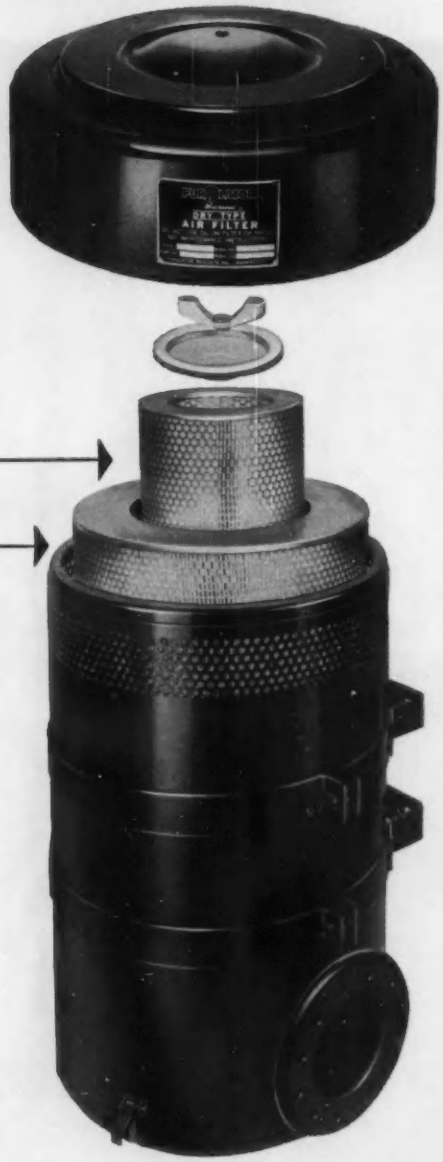
It's Stainless Steel...it's for all Rambler models

Rambler dealers have the answer to the oil control problem, boxed and ready—American Motors KromeX replacement ring sets with Sealed Power Stainless Steel oil rings.

Your overhaul know-how and Stainless Steel oil rings are a winning combination. Stainless Steel rings hold their fit in the cylinder and retain tension at high temperatures. They have chrome-plated side rails for extra long life, seat instantly and are a snap to install.

Chrome-plated compression rings give positive blow-by control, long life and are preseated at the factory for instant seating. Get American Motors KromeX ring sets with all these advantages from your Rambler dealer.

Manufactured by **Sealed Power Corporation** Muskegon, Michigan



an element here

and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation

IT'S THE NEW PUROLATOR TWO-STAGE FILTER

Simplicity of design makes the first cost of Purolator's new dry-type two-stage filter as low as any two-stage filter on the market. Each element filters independently, and together they dustproof your engine as no other filter can . . . 99.98% efficient.

Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Another big user-advantage is the way the two-stage design protects the engine despite accidental mishandling of the element. Even if the first stage element is damaged, the chance of harming the engine can be discounted when it is protected with the second stage back stop element. In addition, the second stage element lets the operator service the unit in the field, regardless of how dusty the conditions are.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic impregnated cellulose. This series of two-stage filters is rated from 450 to 1150 cfm, with exceptionally low initial restriction. Mounting straps, rainhoods and outlet adapters are available.

For more information write to Purolator Products, Inc., Department 3896, Rahway, New Jersey.

Purolator Products, Inc.
Dept. 3896, Rahway, New Jersey

Please send me complete data on the new Purolator two-stage filter series.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Filtration For Every Known Fluid

PUROLATOR

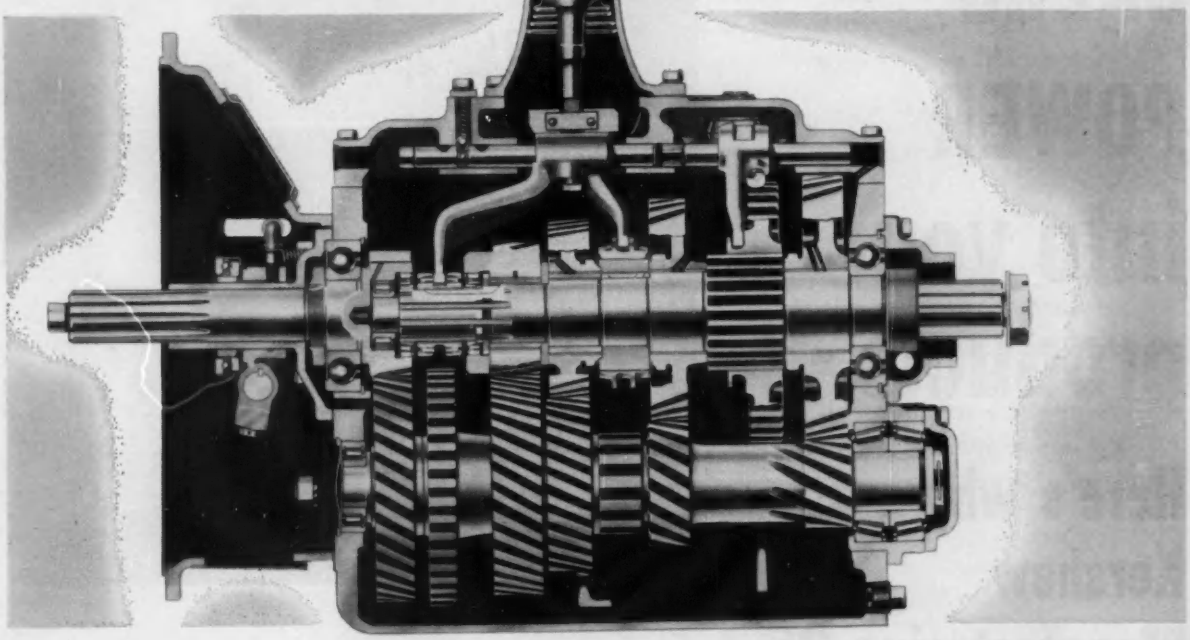
PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, CANADA

New Light Heavyweight...

FULLER

Models 5-H-74
5-HA-74*



the lightest transmission designed for diesel engines—from 190 hp to 250 hp

In keeping with the trend toward high capacity, light-weight components, Fuller has released its new Model 5-H-74 5-speed Transmission.

The NEW 5-H-74 offers:

- * **Model 5-HA-74... even *lighter* weight — 93 lbs. less — with *aluminum* case and clutch housing**
- **mainshaft of greater diameter**
- **high capacity mainshaft pilot bearing**
- **wide gear faces**
- **all helical gearing—low tooth pressures**
- **short, quick shifts—jaw clutch engaged**
- **short installation—25 11/64" in length**
- **extremely high ratio of capacity to weight**

SPECIFICATIONS
Gear Ratios

5th	1.00
4th	1.17
3rd	1.98
2nd	3.61
1st	6.60
Rev.	6.51

Weight:
Model 5-H-74—461 lbs.
*Model 5-HA-74—368 lbs.

Oil Capacity: 12 quarts.

Length: 25 11/64 inches.

FULLER TRANSMISSION DIVISION
EATON MANUFACTURING COMPANY
KALAMAZOO, MICHIGAN

Sales & Service: West. Dist. Branch, Oakland 6, Cal. • Southwest Dist. Office, Tulsa 3, Okla. • Automotive Prod. Co., Ltd., Automotive House, Great Portland St., London W. 1, Eng., European Rep.

How to design SALES POWER into your products

Here's why Kershaw Manufacturing Co. specifies International Power

An International UB-220 gasoline engine powers this Kershaw Ballast Regulator. The machine works in either direction, has forward and reverse speeds up to 26 mph. Engine accessibility promotes quick and easy service—another International feature.

ENGINEERING . . . **Chief Engineer John Holley** backs up his preference for International power with these facts: "We specify International engines for our heavy-duty machines because they best meet the demands of the job. The wide range of sizes, choice of fuels, and power adaptability let us fit the engine to exactly meet machine requirements. Design problems are virtually eliminated, and we get excellent cooperation and assistance from IH engineers."

SALES . . . . . . **Vice President R. C. Crosby** has this to say about the selling advantages of International power: "Kershaw customers want equipment that will deliver maximum dependability at lowest cost. Our experience, over many years, proves that International power meets these high standards of efficiency. Also, replacement parts are readily available. Maintenance of RR right-of-way often takes our machines to remote areas, but IH engine distributors or dealers are always nearby."

PERFORMANCE . . . **Measure the advantages** of International power. First, you get a wide selection of sizes—35 models from 16.8 to 385 max. hp—available in gasoline, LP gas, natural gas or Diesel. Second, you get dependable power that meets the most rigid performance requirements. Third, your product and reputation are backed by International's widespread parts and service organization.

When you specify International you get desirable engineering advantages and extra sales features, plus the built-in benefits that customers demand. Check the International line today, and find out how easy it is to design Sales Power into your products. Call or write to International Harvester Co., Engine Sales Dept., Melrose Park, Ill.

INTERNATIONAL® ENGINES

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.

A COMPLETE POWER PACKAGE

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Steel *for Strength . . . Economy . . . Versatility*

Flame-Hardening Alloy Steels

The process known as flame-hardening involves the direct application of flame to the surface of steel, heating it above the transformation range, then hardening it by quenching. The primary purpose of this process is to achieve surface-hardness without affecting core properties. Jets of flame are played directly on the steel, and hardness penetration can be made to vary considerably. In alloy steels this depth will range usually from 0.03 to 0.12 in., the actual figure depending upon the method of heating and quenching used.

Unlike carburizing, flame-hardening does not involve the absorption of extraneous elements by the steel. There is no alteration of the chemical composition. To put it simply, the steel must have its own self-hardening characteristics; it cannot be dependent upon carbonaceous salt baths, gases, and other media.

Flame-hardening is not a substitute for the conventional furnace method. Each has its uses. The particular virtue of flame-hardening is that the flames can be directed to localized areas. The furnace, on the other hand, is generally more economical and feasible when parts produced in large quantities must be hardened all over.

Any type of hardenable steel, alloy or carbon, can be flame-hardened, and there will usually be no scale or pitting. The alloy content is the governing factor when determining the quench. In some cases a rapid quench is required; in others, it can be as slow as air-cooling. Tempering presents no problems, for flame-hardened steel can be tempered as if hardened to the same degree by other methods.

A list of typical flame-hardened parts includes such familiar items as gear and sprocket teeth, and certain types of cams and rollers, and shoe treads. A complete list would include many other parts that often require a localized hardening treatment, especially for wear-resistance.

When you need information about flame-hardening methods, please feel free to consult with our technical staff. Bethlehem metallurgists will work with you, at no obligation, and you can depend on their suggestions. You can rely on Bethlehem, too, as a source of alloy steels . . . for Bethlehem makes the complete range of AISI standard grades, as well as special-analysis steels, and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

The versatile EATON 2-SPEED AXLE gives higher truck performance for them all!

With double the conventional number of gear ratios, the Eaton 2-Speed Axle gives truckers the gear versatility necessary for more efficient truck performance on or off the highway, or in city traffic — all in one truck.

"Low-low" gives the driver the right gear to operate with a steady, powerful crawl under full capacity load. He can pull out on the open highway and easily and quickly shift into "high" range for time-saving, dollar-making road speeds—uphill or down—either loaded or empty. He can keep rolling at best speed — even in city traffic.

Whatever a truck needs to do, the Eaton 2-Speed Axle will keep the engine turning in the most efficient range—while stretching out its life and the life of *all* power transmitting parts. Operators get more vehicle time on the job—lower maintenance costs—less operating expense.

Give your customers *all* the facts on versatile Eaton 2-Speed Axles.

EATON

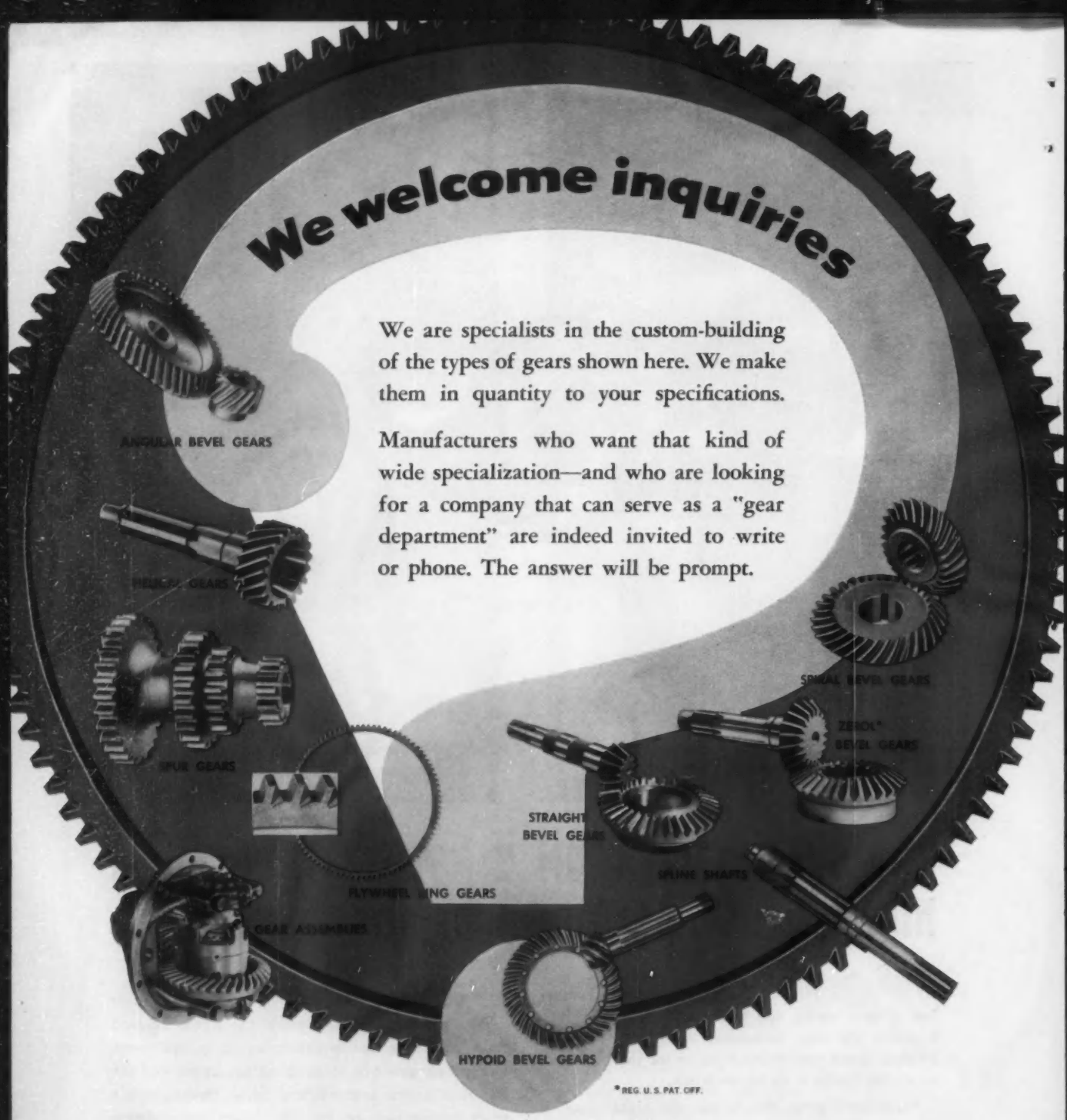
AXLE DIVISION
MANUFACTURING COMPANY
CLEVELAND 10, OHIO

...Your partner in progress through research...

We welcome inquiries

We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.

Manufacturers who want that kind of wide specialization—and who are looking for a company that can serve as a "gear department" are indeed invited to write or phone. The answer will be prompt.

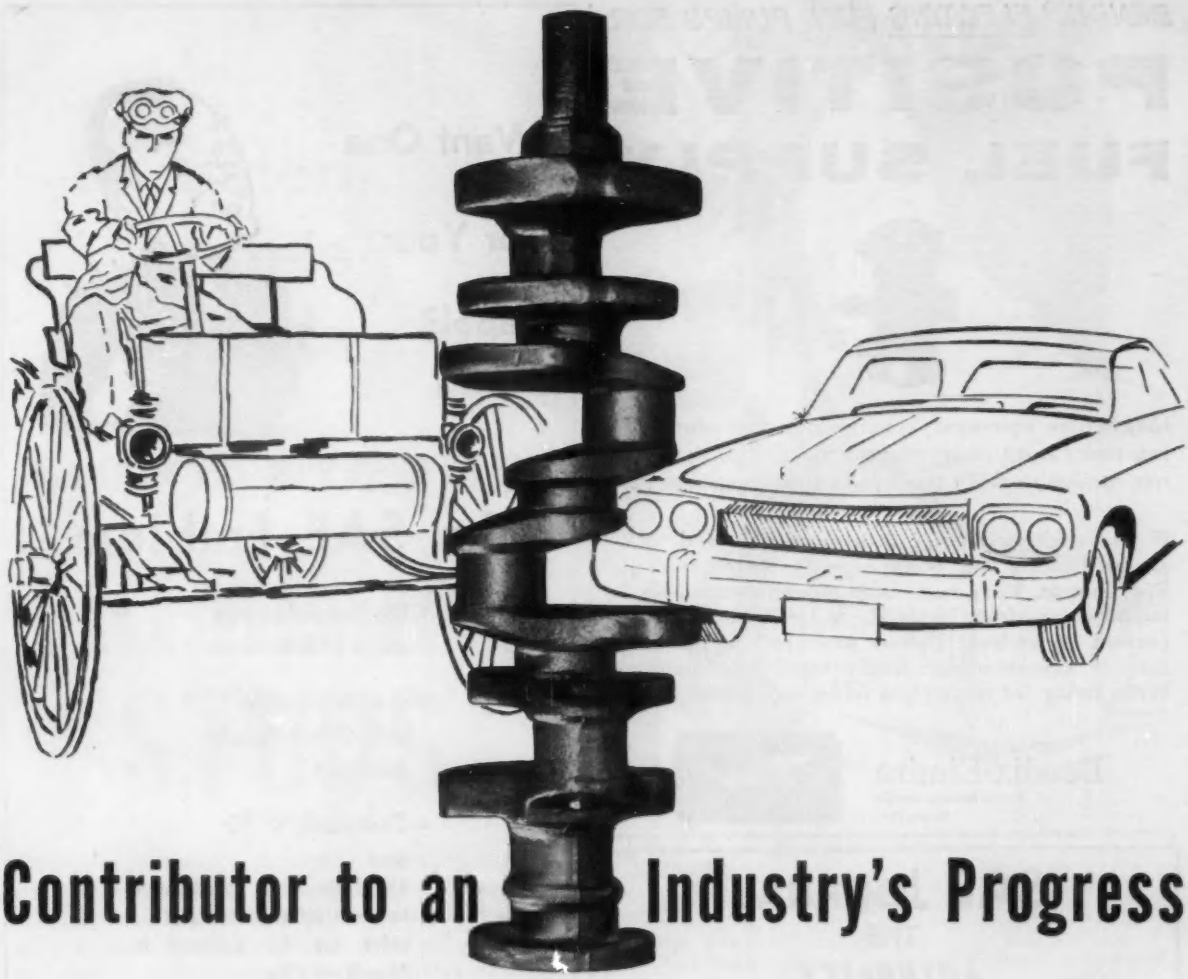


*REG. U. S. PAT. OFF.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS



Contributor to an Industry's Progress

Wyman-Gordon crankshaft forgings meet every design challenge

From horseless carriages of yesteryear to the sleek cruisers and lithe compacts of today, thousands of engine designs have come off the industry's drawing boards. Each has posed new problems, new challenges to the crankshaft producer as the stresses generated by the demand for higher power and efficiency continue. Through the years Wyman-Gordon contributions to power-plant progress have been decisive. Advances in forging techniques, metallurgy and control of flow patterns have made Wyman-Gordon forged crankshafts the acknowledged standards of reliability in every era. But progress never stops—for new engine developments, still in the design stage, will benefit as much from Wyman-Gordon know-how as have those of past decades.

FORGED

EST. 1883

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA FORT WORTH TEXAS

BENDIX® ELECTRIC FUEL PUMPS FOR

POSITIVE FUEL SUPPLY

AGRICULTURAL EQUIPMENT / CONSTRUCTION EQUIPMENT / CARS
TRACTORS / BUSES / SHOP TRUCKS / TRUCKS / EARTH MOVERS
FIRE ENGINES / BOATS / TANKS / HEATERS / GENERATOR SETS

If you engineer any of these products—and want an outstanding fuel pump—specify Bendix Electric Fuel Pumps. They have been proved dependable in temperatures from +150°F. to −76°F. Positively prevent vapor lock. Deliver more gallons per hour. Built-in pressure release. Easily installed and serviced. Write today for descriptive folder and specifications.

Bendix-Elmira
Eclipse Machine Division
Elmira, N.Y.

THE Bendix CORPORATION

SAE JOURNAL
THE
AUTHORITY
ON
AUTOMOTIVE
AND
AIRCRAFT ENGINEERING
SAE JOURNAL
485 Lexington Ave., N. Y. 17, N. Y.

For any automotive use of

MOLDED FIBER GLASS

Call the pioneers and experts.
Free literature, counsel and quotations.
No obligation. Write:

Molded Fiber Glass Body Co.
4639 Benefit Avenue • Ashtabula, Ohio

Want One For Your Lapel?

An SAE Emblem

- Distinguishes you as an SAE member
- Is an attractive gold-filled clutch-back pin
- Costs only $1.50
  plus
  15¢ Federal tax for delivery in the United States and 5¢ sales tax for delivery in New York City

ACTUAL SIZE

GOLD on BLUE ..... Member Grade
GOLD on RED ..... Associate Grade
GOLD on WHITE ..... Junior Grade

Society of Automotive Engineers
485 Lexington Ave., New York 17, N. Y.

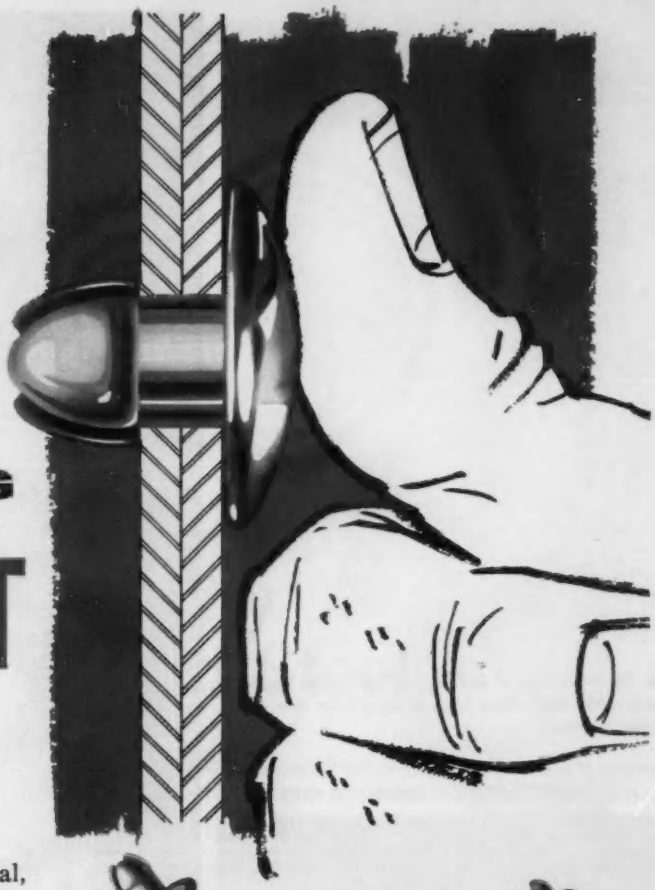
Please send me an SAE emblem. Enclosed is my check for $..... ($1.50 plus applicable taxes). Grade of membership (please check)

☐ Member ☐ Associate ☐ Junior

Name .....
(PLEASE PRINT)

Address .....

to fasten
panels
or parts . . .



LIGHT, STRONG

TRIMOUNT STUDS

Designed for rapid assembly of sheet-metal, plastic or composite structures, Dot Trimount studs are available in both permanent and removable types. They can be pushed into drilled, stamped or molded holes by finger-pressure alone yet they lock positively in place and resist constant vibration.

Studs can be designed in steel or brass with various flange configurations for clinch, clip or clamp attachment to flexible or rigid panels as well as for push-through assembly. Available in all standard finishes . . . with or without decorative caps.

Push Rivet Stud Shoulder Type (Capped)
Push Rivet Stud Tapered Type (Capped)
Push Rivet Stud Shoulder Type (Not Capped)
Push Rivet Stud Tapered Type (Not Capped)
Clinch Type Stud
Clip-on Stud
Trim Stud Barrel Type
Trim Stud Scissors Type
Panel Type Stud
Loop Type Stud
Panel Stud Staple Type
Panel Stud Hook-on Type

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on Dot's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements.

► *For further details, write for Engineering Data Catalog, Section H*

MAKERS OF DOT FASTENERS

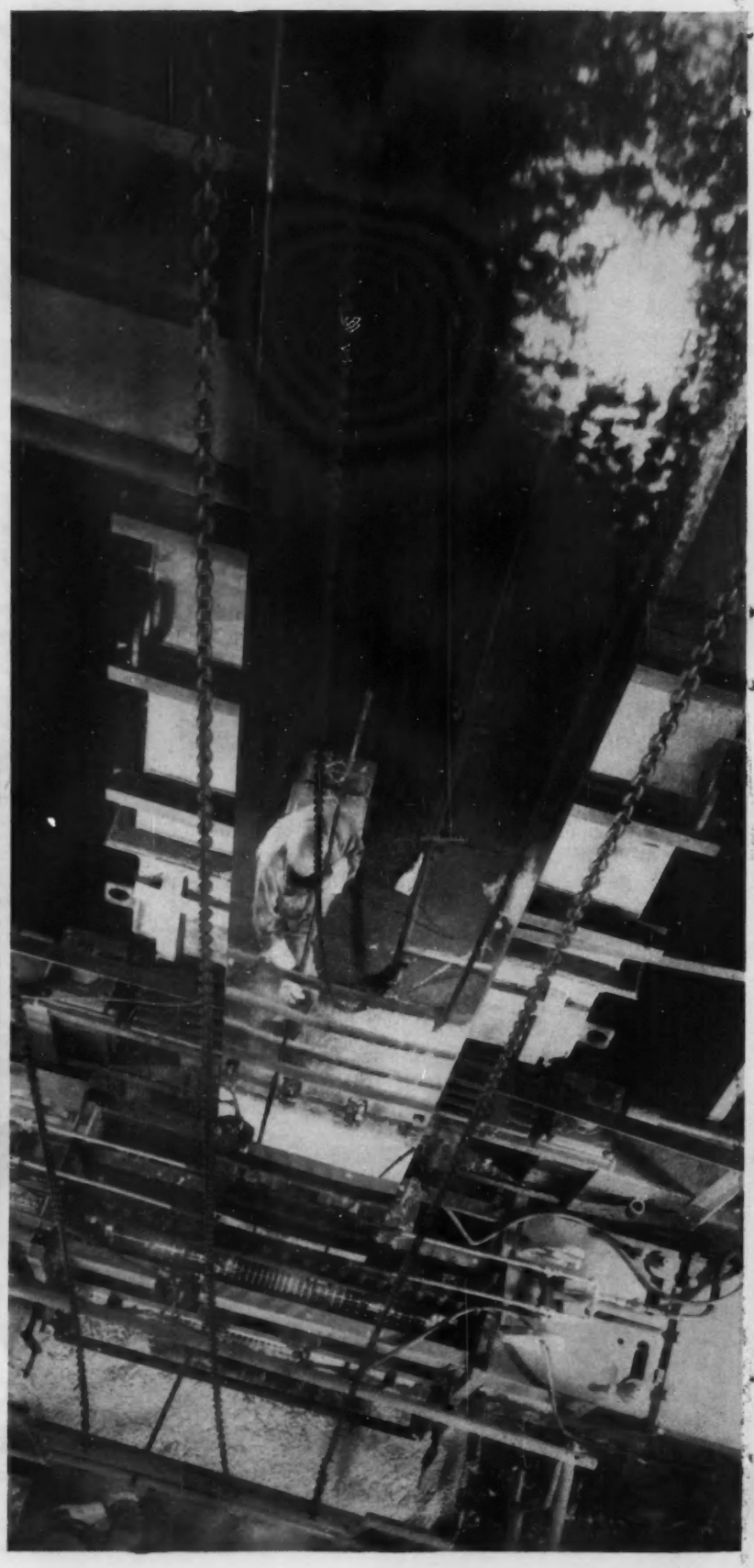
CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse

In the production of continuously zinc-coated steels, Armco has many more years of experience than any other producer.

Because it eliminates this, double muffler life provided by Armco ALUMINIZED STEEL is good news to car owners.



Steel

This symbol stands for economical, durable modern steels.

Design for Durability with Armco Coated Steels

New steels are born at Armco

For strength at low cost, steel is still the best answer. And special Armco Steels, with coatings of zinc and aluminum, offer unmatched selection for *durability*, too, in automotive parts.

Armco Steels with specially applied hot-dip coatings of zinc or aluminum are more than "just steel." They are designers' materials with built-in durability and properties tailored to specific needs.

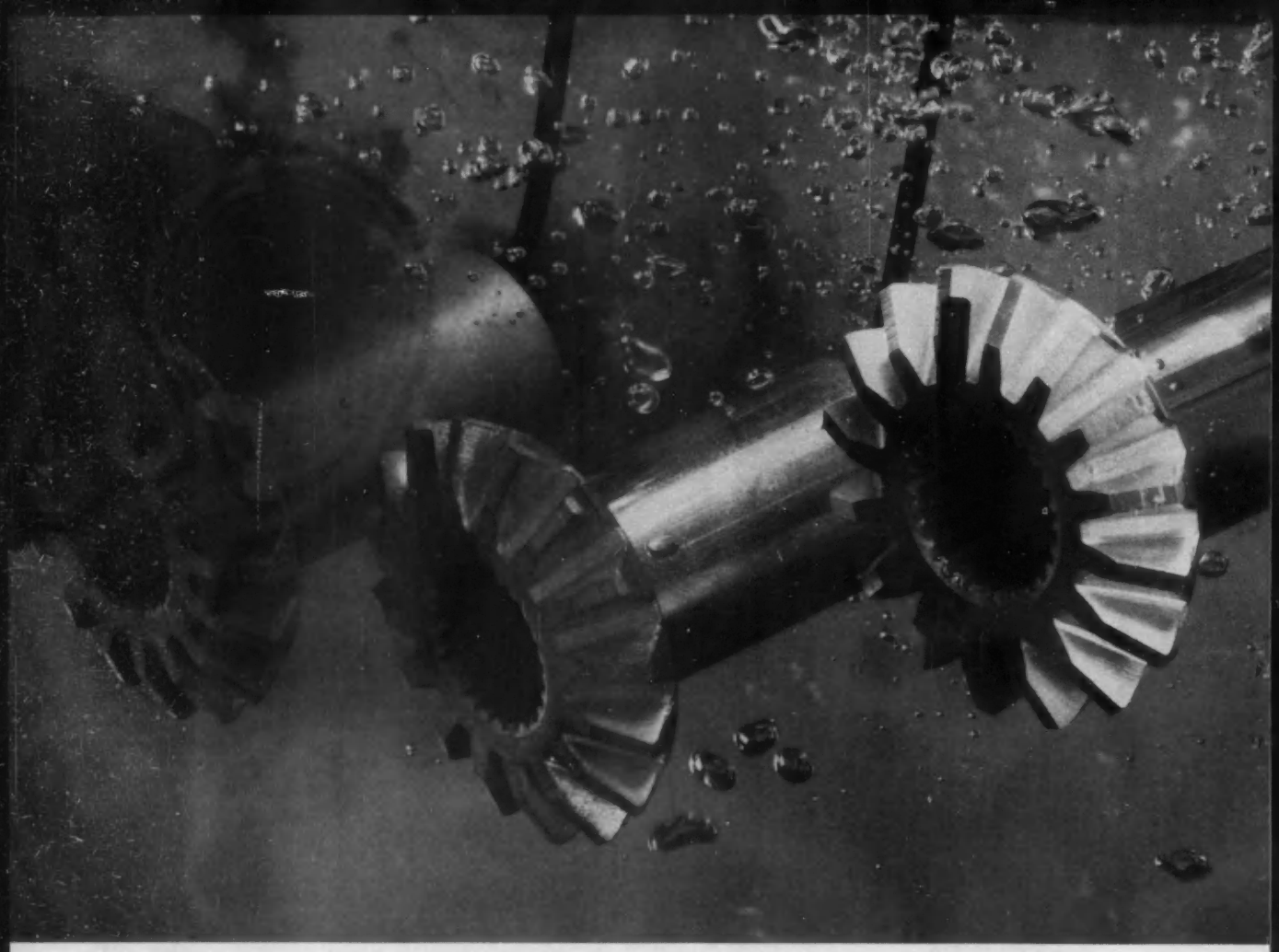
Armco ZINCGRIP®, the original continuously hot-dip zinc-coated steel, has spawned a versatile family of coated steels. All offer top rust resistance and workability. Each offers specific qualities, such as spangle-free, minimized, or full-spangle zinc coating; differential coating; mill-treated surface for painting; tailored base metal properties.

In exhaust system parts, economical Armco ALUMINIZED STEEL (aluminum-coated) shows excellent resistance to combinations of heat and corrosion.

When you design for durability, consider this group of low-cost, special Armco Coated Steels. Call your nearest Armco Sales Office or write **Armco Division, Armco Steel Corporation, 2481 Curtis Street, Middletown, Ohio.**

Armco Zinc-Coated Steels promise greater life for body parts.

ARMCO **Armco Division**



NEW SAFETY SOLVENT permits

on-the-line cold degreasing . . . 100% parts inspection

FAR GREATER SAFETY than most other chlorinated solvents makes Chlorothene® NU specially inhibited 1,1,1-trichloroethane ideal for the cold removal of greases, waxes, tars, and oils. In cleaning for spot inspection of close tolerances, or for 100% inspection as on broaching machine operations, Chlorothene NU may be used quickly and safely by spray, dip, bucket or wiping methods. Die parts may be cleaned in the shop without having to send them out for vapor degreasing.

By providing answers to both of the chief hazards of common cold-degreasing solvents, Chlorothene NU is leading a breakthrough in solvent cleaning. Having *no* fire or flash point measurable by standard methods, it is removed from the flammable class of cleaning compounds. Maximum allowable vapor concentration of Chlorothene NU solvent is a high 500 ppm, compared to carbon tetrachloride at 25. Chlorothene NU is easily recovered by distillation. It can be used safely on most electric motors, instruments, bearings, and on all common metals including aluminum, zinc, corrosion-prone "white-metal" alloys, and on many plastics.

HYDRAULIC FLUIDS continue to be important objects of research at the Dow Automotive Chemicals Laboratory. They are custom engineered, and Dow's broad background in polyols, glycols, and glycol ethers assures hydraulic fluids of the highest quality, and with an almost limitless range of properties.

VORACEL® foamed-in-place rigid urethane offers new advantages for sound deadening, insulating, "pocket" sealing, and strengthening between structural members. The new process gives a superior, and economically feasible covering and filling material for many automotive uses. For additional information, contact your nearest Dow sales office.

DOW AUTOMOTIVE CHEMICALS LABORATORY

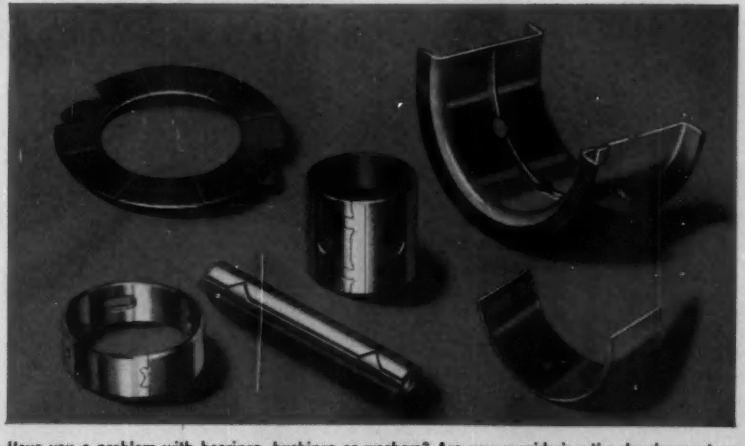
Created expressly to serve the needs of the automotive industry, Dow's Automotive Chemicals Laboratory is active in technical service and development. This laboratory is continually researching and developing coolants, hydraulic fluids, cutting and grinding fluids, function fluids, fuel and lubricant additives, and synthetic lubricants. To see how this laboratory can be of assistance to you, contact your nearest Dow sales office or write Chemicals Merchandising in Midland.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

75-MILLIONTHS OF AN INCH BARRIER HALTS METAL MIGRATION

JUST BENEATH THE FRESH OVERPLATE OF THESE F-M ENGINE BEARINGS (LEFT) LIES A TENUOUS DIFFUSION BARRIER. Though this film of metal is only 75-millionths of an inch thin, it stops tin in the overplate from migrating into the lining metal beneath. Its presence is important to bearing overplate performance, particularly during the critical period of engine break-in. Maintaining uniform thinness as well as uniform composition of the plated barrier is most important . . . and most difficult to achieve on a production scale. Federal-Mogul research has developed a unique, extraordinarily precise method for controlling both the thinness and the metallic composition of this barrier, within narrow limits. And the performance of F-M engine sleeve bearings attests to the success of the method!

RESEARCH INTO ELECTROPLATING problems is a continuing project in the F-M laboratories. Unusual precision equipment and facilities are employed, many of which have been specially designed and engineered by F-M to solve problems of sliding-bearing application. As a result, Federal-Mogul engineered sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers provide the finest possible performance characteristics for any application.



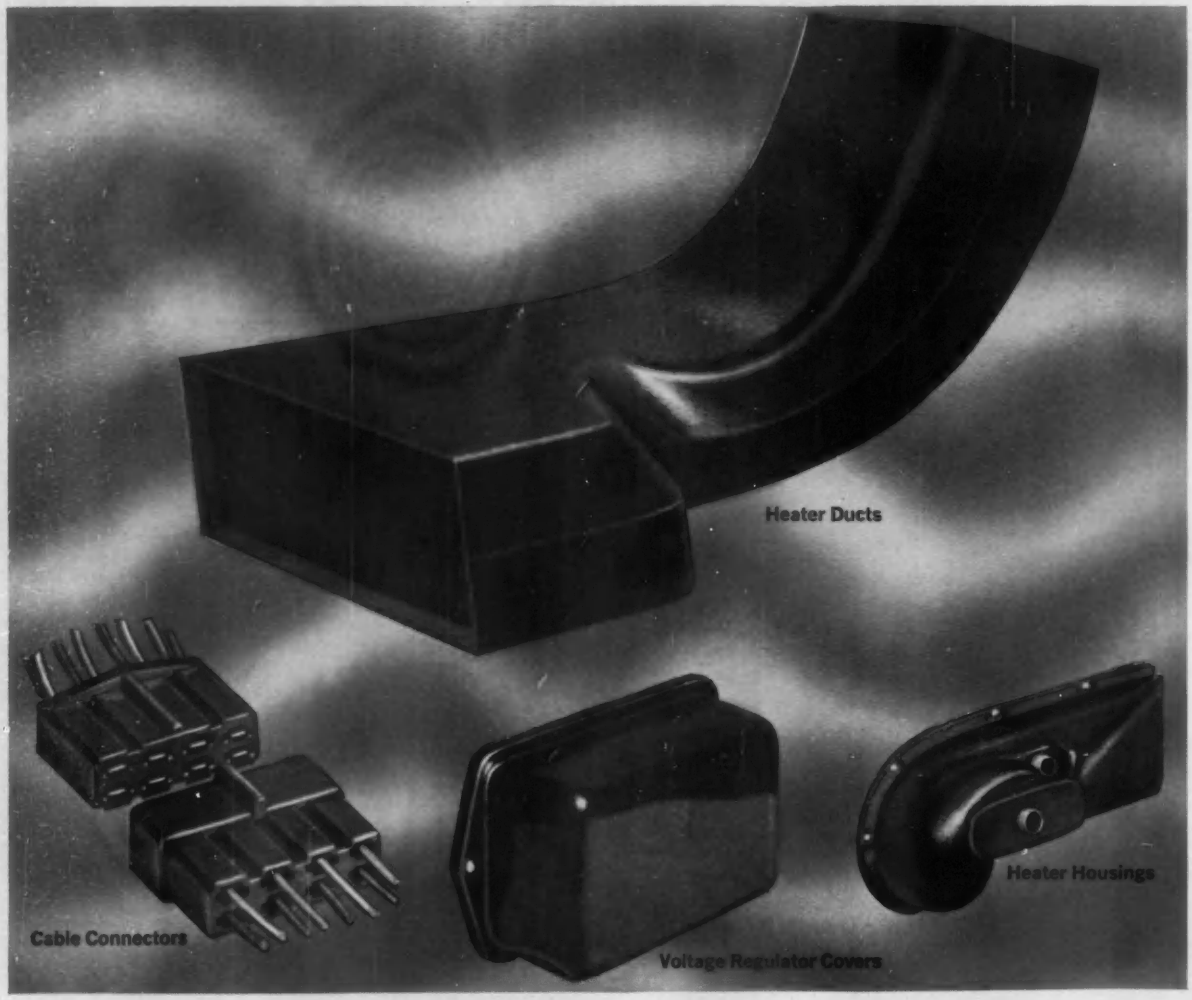
Have you a problem with bearings, bushings or washers? Are you considering the development or redesign of an item of the type shown above? We'll be glad to show you how the job can be done most effectively and economically. For information, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings · spacers
thrust washers

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

What's News in Plastics...



Long term heat aging stability

Yours with new Escon® 125 molding grade polypropylene!

Automotive applications are a "natural" for new Escon 125 polypropylene. This outstanding new grade is designed especially to maximize performance for long periods at high temperatures. Exceptional performance is achieved through a special LTHA (Long Term Heat Aging) stabilization system developed by Enjay research affiliates.

Escon 125 offers oxidative stability that, in carefully conducted laboratory tests against other commercially available grades of polypropylene designed for this type of service, outperformed all others tested. Specimens of Escon 125 withstood almost three months of oxidative aging at 300°F; specimens exposed to 250°F have shown no signs of failure after seven months. Melt index is 5.5 at 230°C. No changes are required in equipment, processing conditions or coloring techniques from those used with general purpose molding grades. For test samples and typical properties of new Escon 125, write to Enjay, 15 W. 51st St., New York 19, N.Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

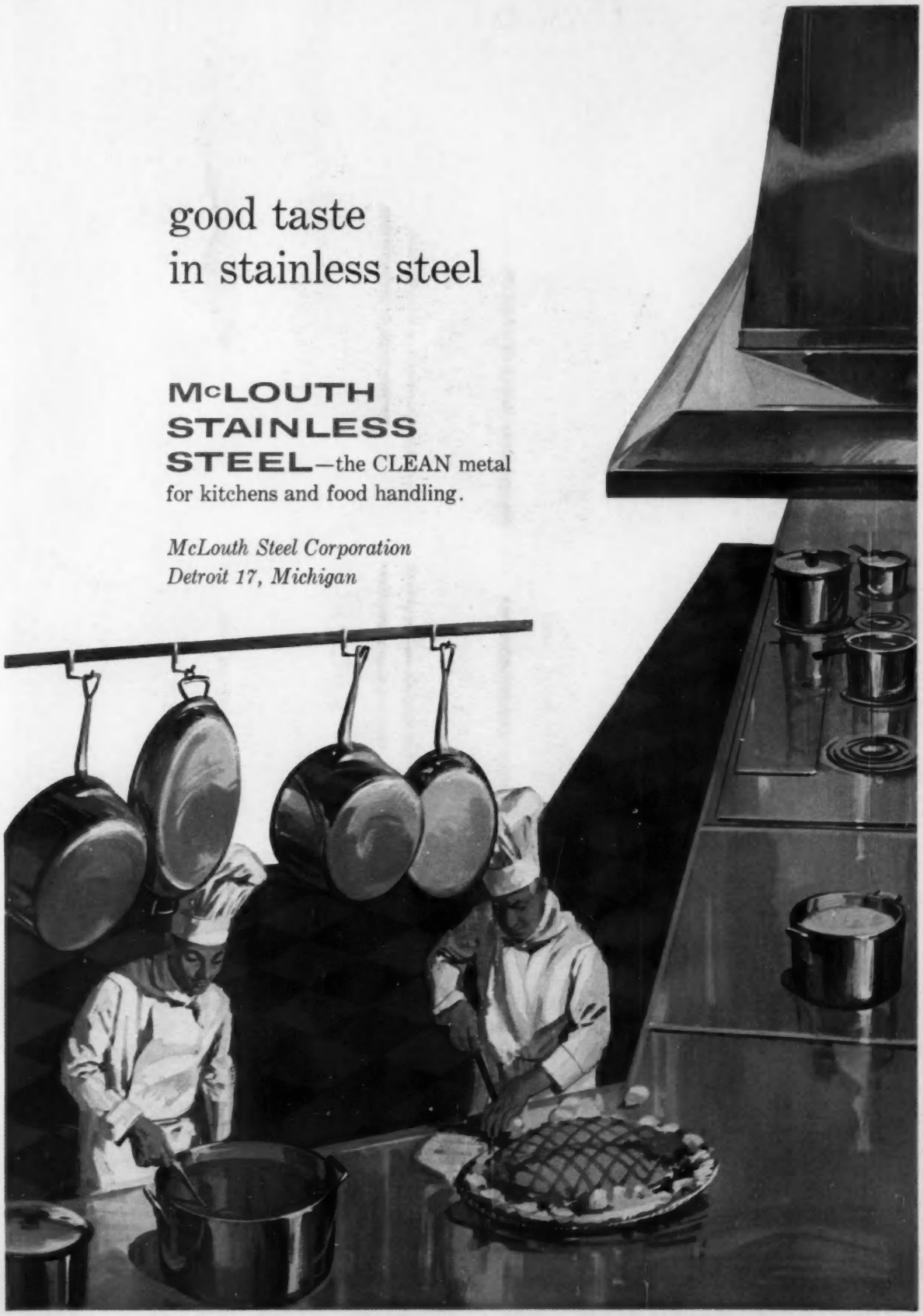
A DIVISION OF HUMBLE OIL & REFINING COMPANY

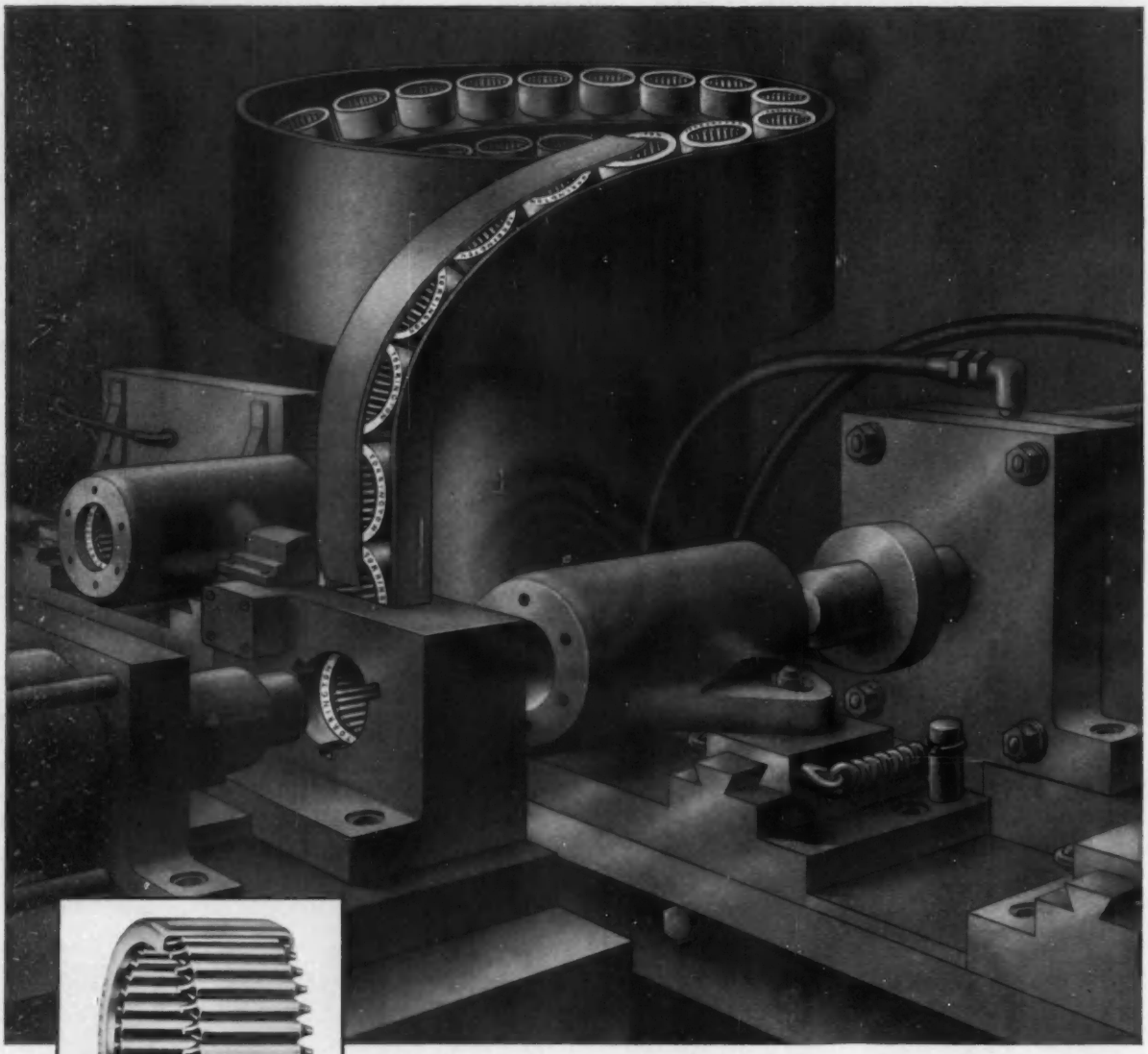
ENJAY PLASTICS

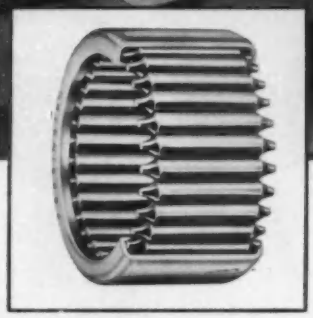
good taste
in stainless steel

McLOUTH STAINLESS STEEL—the CLEAN metal for kitchens and food handling.

McLouth Steel Corporation
Detroit 17, Michigan







TORRINGTON NEEDLE BEARINGS FEATURE:

- ☐ Unique unit construction
- ☐ Full complement of retained rollers
- ☐ Unequalled radial-load capacity
- ☐ Low coefficient of starting and running friction
- ☐ Low unit cost
- ☐ Long service life
- ☐ Compactness and light weight
- ☐ Run directly on hardened shafts
- ☐ Permit use of larger and stiffer shafts

It's easy as 1–2–3 with . . .

LOW-COST TORRINGTON NEEDLE BEARINGS! They can be installed easier and faster than any other type of anti-friction bearing. There's no waste time . . . no waste motion. No collars, shoulders or retaining rings to complicate assembly. Just one quick ram stroke . . . and the Torrington Needle Bearing is completely and firmly installed.

These exceptionally low-unit-cost and assembly advantages are yours whether you're geared for large volume, high-speed runs on automated machines . . . or lower volume, lower-speed assembly on simple arbor presses. Either way, you'll find it pays to specify Torrington Needle Bearings.

Torrington Needle Bearings offer other outstanding design and performance benefits. For details on how they can help you, call or write us today.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

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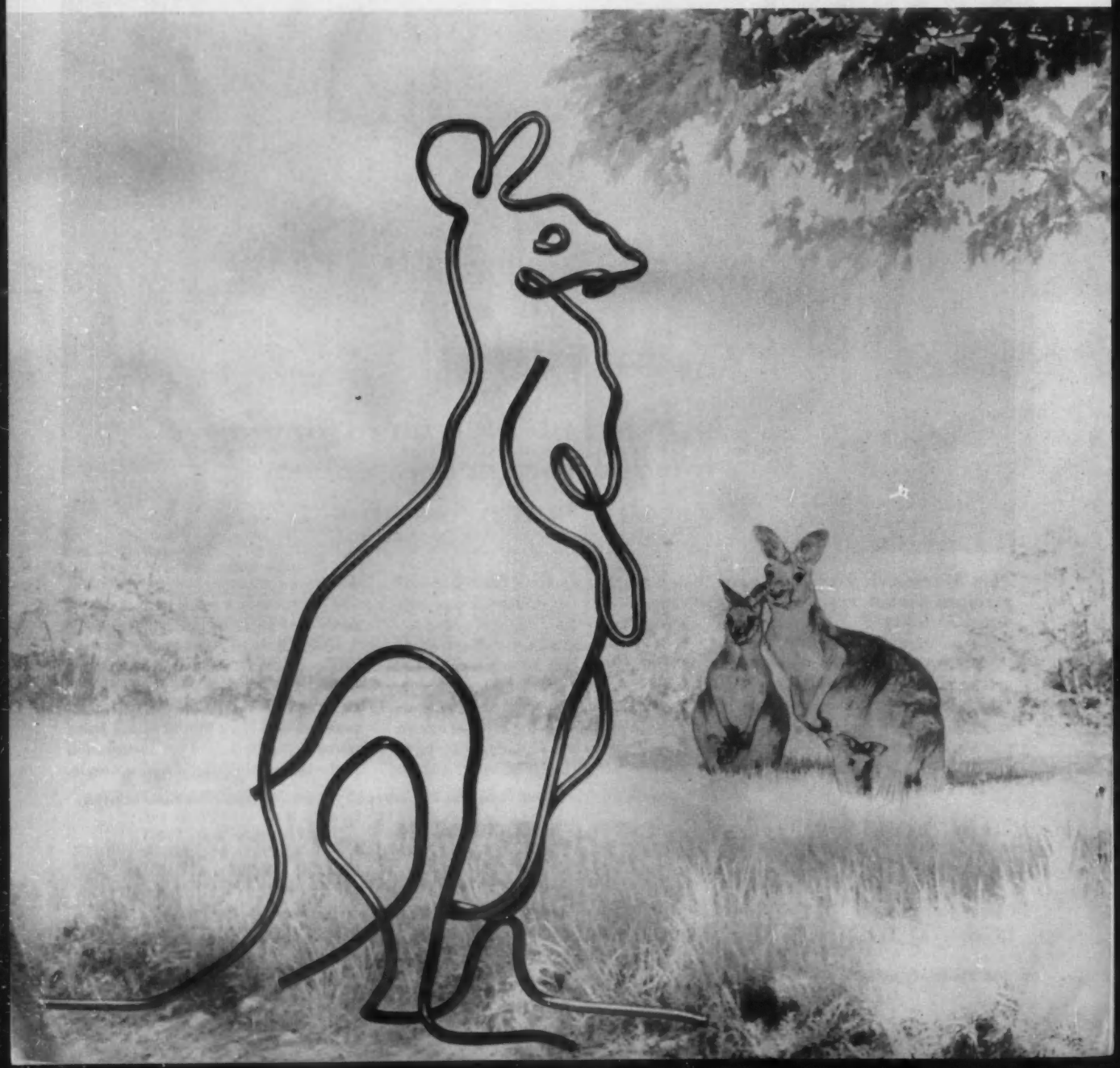

Want top-quality tubing at mass-fabrication cost? Bundy can give it to you for virtually every tubing requirement . . . for simple or complex shapes, one bend or many. One big reason is Bundyweld® steel tubing: standard wall thickness and O.D. are held to +.002" to −.003", and it meets Gov. Spec. MIL-T-3520, Type III; ASTM 254; and SAE Specifications. Another reason is Bundy's mass-fabrication facilities themselves, tailored by tubing specialists to give you the lowest possible cost compatible with high quality. Talk to Bundy to find out how you can save money on tubing. Call, write, or wire: Bundy Tubing Company, Detroit 14, Michigan.

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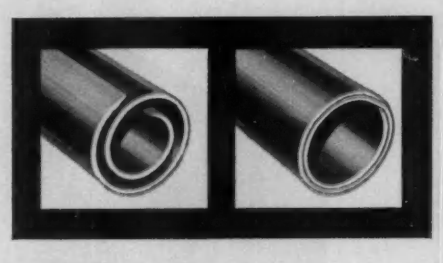

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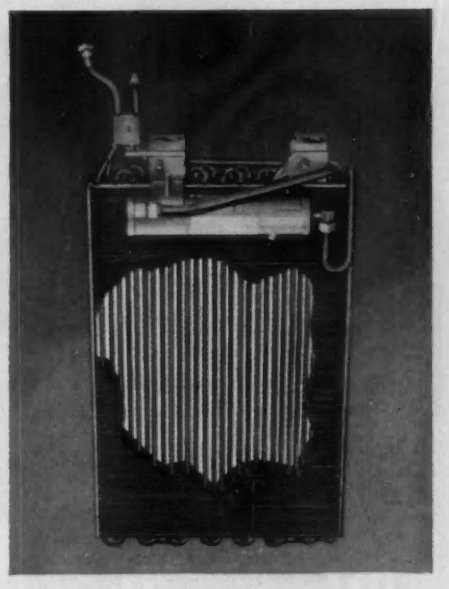

Ford owners ride in cool comfort with this factory-installed air conditioner. Bundyweld steel tubing used in the condenser coil and connecting tubes not only provides leakproof dependability, but also makes important cost savings possible.

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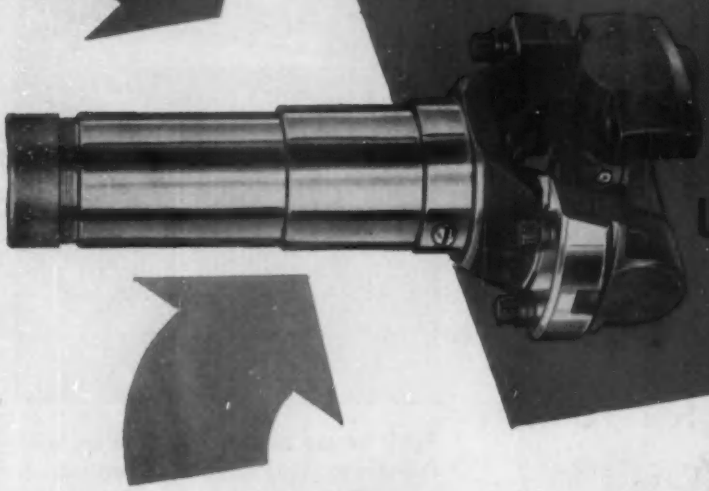

To meet new drive line requirements on its 1961 model trucks, a major truck manufacturer needed a special, lightweight but strong universal joint—a unit that would provide greater torque capacity without increasing swing diameter. Rockwell-Standard engineers were consulted, and in a cooperative effort the new "58WB" was developed. It is now being used on several models in the manufacturer's 1961 line.

The design of the new "58WB" is applicable to medium-weight trucks, off-highway equipment, small crawlers and front-end loaders of approximately 1½ yards capacity. It can be made up as a complete drive line, furnished as a component part for a manufacturer's own drive line, or utilized in close-coupled drives. The "58WB" offers these outstanding advantages:

★ **More capacity than any joint of comparable size.** The "58WB" provides 39,000 inch pounds torque capacity with a swing diameter of only six inches!

★ **Key-type yoke.** Requires only four bolts for installation on original equipment. Saves downtime for repairs.

For more details about the new "58WB" or for help in solving any problems involving universal joints or drive lines, write or call us today.

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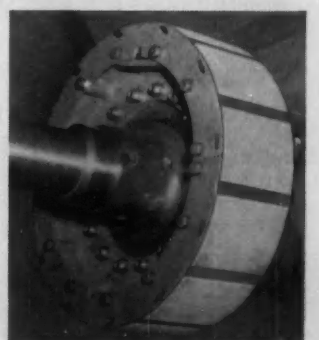
Hi-Torque brakes provide positive control as giant Loader lugs 35 tons

The heavy-duty requirements of this CARY-LIFT Loader, made by Pettibone Mulliken Corporation of Chicago, led to a thorough search for the best brakes available. According to the manufacturer: "Exhaustive tests proved to our entire satisfaction that Hi-Torque brakes were far superior to any other type available to us for our requirements."

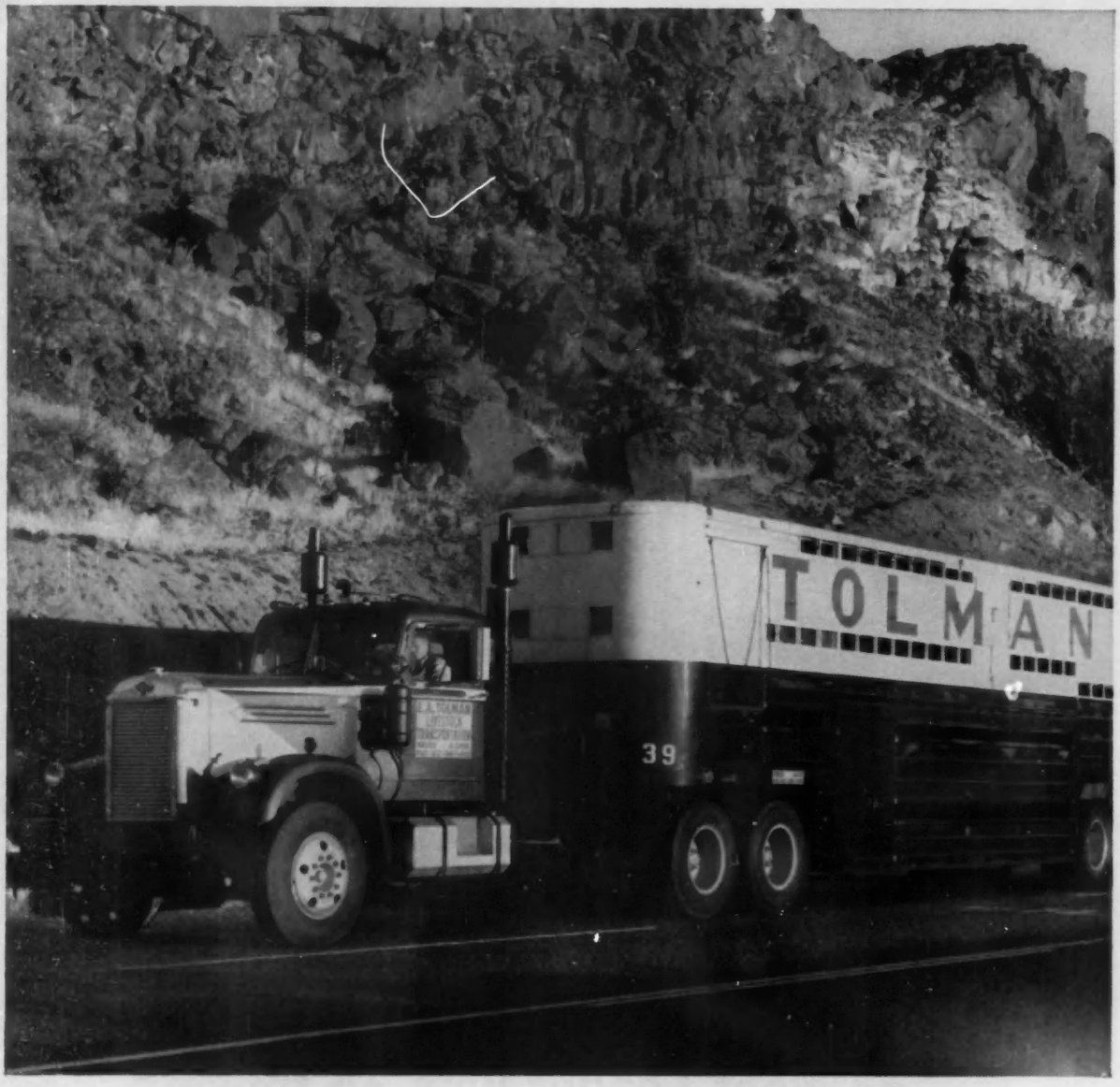
The brakes on these Loaders provide gentle yet positive braking under all conditions, including operation with very heavy loads in snow, mud, and other adverse conditions. In addition to superior braking power, the manufacturer reports simplified assembly operations through standardization on Hi-Torques.

Investigate Hi-Torque brakes for maximum controllability and safety on your heavyweight off-road vehicles. Now available on several makes of Loaders, Trucks, Tractors, Scrapers, Mine Vehicles. For information ask your vehicle manufacturer, or write *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. SJ-8, Troy, Ohio.*



Full circle contact with drum is provided by Hi-Torque brakes giving maximum effective braking surface in the same size unit. Hi-Torque stops vehicles twice as fast as conventional brakes.

B.F.Goodrich **Hi-Torque brakes**



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Nickel alloy steel is used in all mainshafts, countershafts and gears in both the main and auxiliary transmissions in this rig. A carburizing grade of nickel alloy steel is specified because it *combines* the properties of case hardness, core strength and toughness. Readily developed in heat treatment with minimal distortion, this combination of desired properties promotes long life and dependable service in gears and shafts.

Carburized to a depth of .040"-.050", and with a case hardness of 60-62 Rockwell "C", the nickel alloy steel gears and shafts in this unit resist wear, fatigue, spalling and chipping—withstand heavy loads under the most rugged working conditions.

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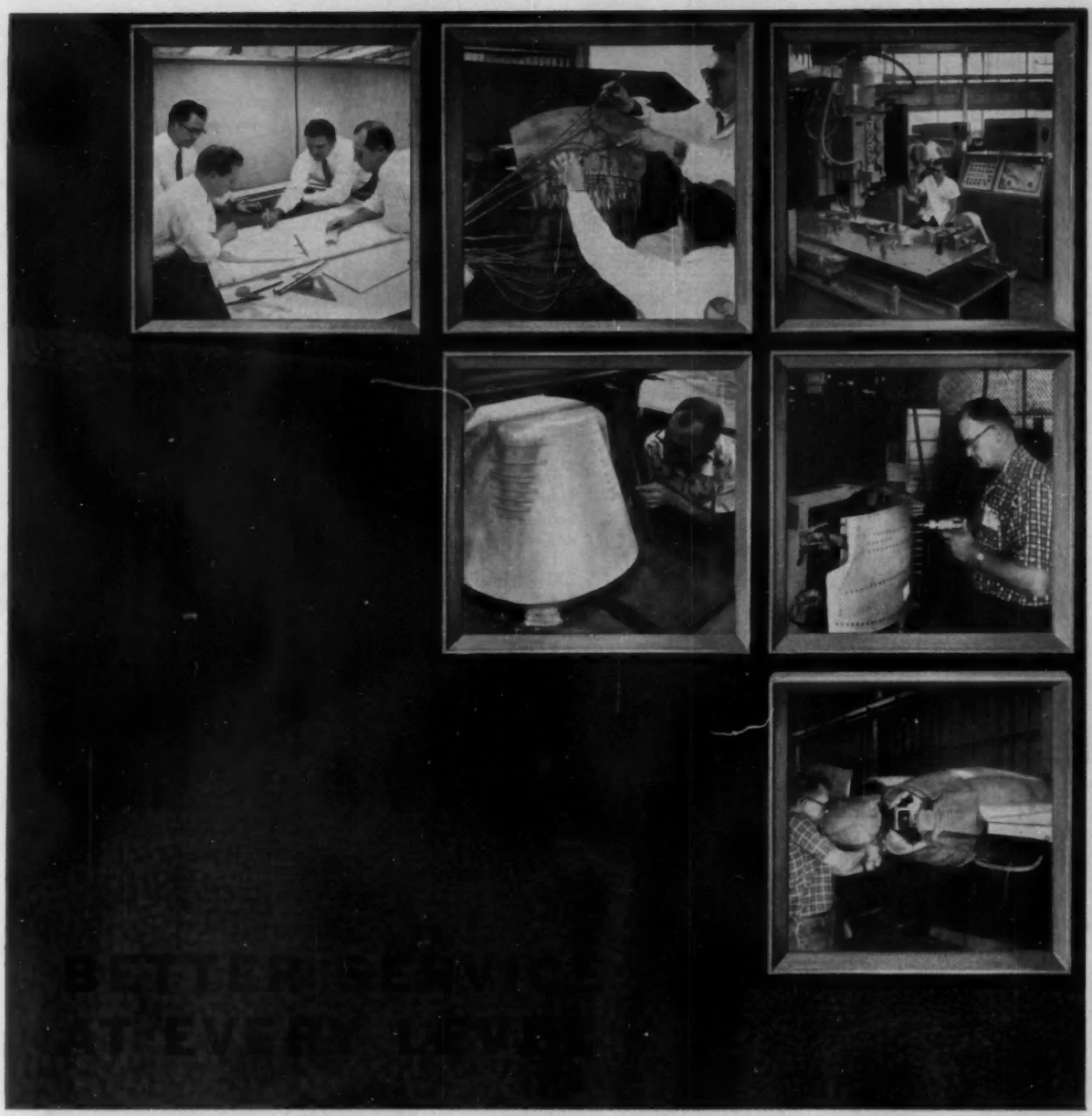

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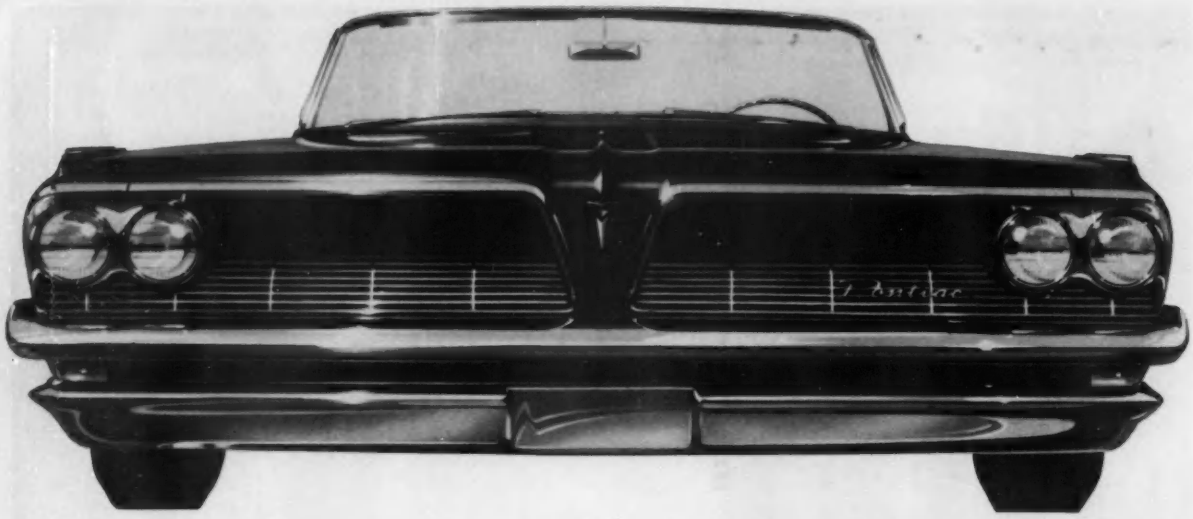

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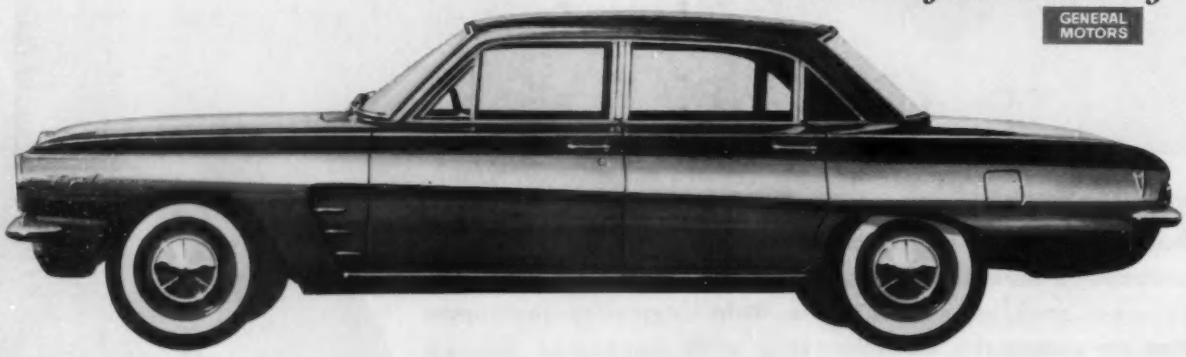

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+ INDEX TO ADVERTISERS +

A

Aetna Ball & Roller Bearing Co.
Div. Parkersburg-Aetna Corp. . 136
AiResearch Mfg. Corp. 167
American Standard Controls Div. . 8
Armco Steel Corp. 160, 161
Automotive Gear Div.
Eaton Mfg. Co. 156

B

Bearings Company of America ... 16
Bendix Corp.
Eclipse Machine — Fuel Pump . 158
Products (General Sales) 30
Bendix Westinghouse Automotive
Air Brake Co. 127, 128
Bethlehem Steel Co. 154
Bower Roller Bearing Div.
Federal-Mogul-Bower Bearings,
Inc. 25
Bryton Chemical Co. 175
Bundy Tubing Co. 168, 169

C

Clark Equipment Co.,
Automotive Div. 148
Continental Motors Corp. 144
Copperweld Steel Co. 135

D

Dana Corp. 14
Delco Radio Div.
General Motors Corp. 9
Delco Remy Div.
General Motors Corp. 12, 13
Dow Chemical Co. 162
E. I. du Pont de Nemours & Co., (Inc.)
Elastomers Div. 26, 27

E

Eaton Mfg. Co.
Axle Div. 155
Engineering Castings, Inc. 140
Enjay Chemical Co., Div. of
Humble Oil & Refining Co.
Escon 164
Evans Products Co. 23

F

Federal-Mogul Div., Federal-
Mogul-Bower Bearings, Inc. ... 163
Fuller Transmission Div.
Subsidiary Eaton Mfg. Co. 151

G

B. F. Goodrich Aviation Products 171
Great Lakes Steel Corp. 146, 147

H

Harrison Radiator Div.
General Motors Corp. 3
Hepworth & Grandage, Ltd. 145
Holcroft & Company 139

I

International Harvester Co. .. 152, 153
International Nickel Co. 172

K

Kelsey Hayes Co. 141

L

Lipe Rollway Corp. 10

M

McLouth Steel Corp. 165
McQuay-Norris Mfg. Co. 21
MATHER ..... 3rd Cover
Mechanics Universal Joint Div.
Borg-Warner Corp. 177
Midland-Ross Corp. 138
Molded Fiber Glass Body Co. 158

N

National Seal Div., Federal-
Mogul-Bower Bearings, Inc. ... 11

P

Palnut Co., Subsidiary
United-Carr Fastener Corp. ... 134
Perfect Circle Corp. ..... 2nd Cover
Phillips Chemical Co. 126
Precision Rubber Products Corp. . 24
Purolator Products, Inc. 150

R

Raybestos-Manhattan, Inc.
Adhesives Dept. 143
Equipment Sales Div. 142
Reynolds Metals Co. ... 17, 18, 19, 20
Rochester Products Div.,
General Motors Corp. 174
Rockwell Standard Corp.
Brake Div. 7
Transmission & Axle Div. 133
Universal Joint Div. 170
Rohr Aircraft Corp. 173

S

Schlegel Mfg. Co. 22
Screw & Bolt Corp. of America ... 15
Sealed Power Corp. 149
Stackpole Carbon Co. 129
Stratoflex, Inc. 137

T

Timken Roller Bearing Co. . 4th Cover
The Torrington Co. 166

U

United-Carr Fastener Corp. 159
U. S. Rubber Co., (Naugatuck
Chemicals) 4

W

Warner Automotive Div.,
Borg-Warner Corp. 130
Webster Electric Co. 28
Wico Ignition Div.,
Globe-Union Inc. 133
Wooster Div.
Borg-Warner Corp. 131
Worthington Corp. 175
Wyman Gordon Co. 157

XYZ

Zollner Corp. 178

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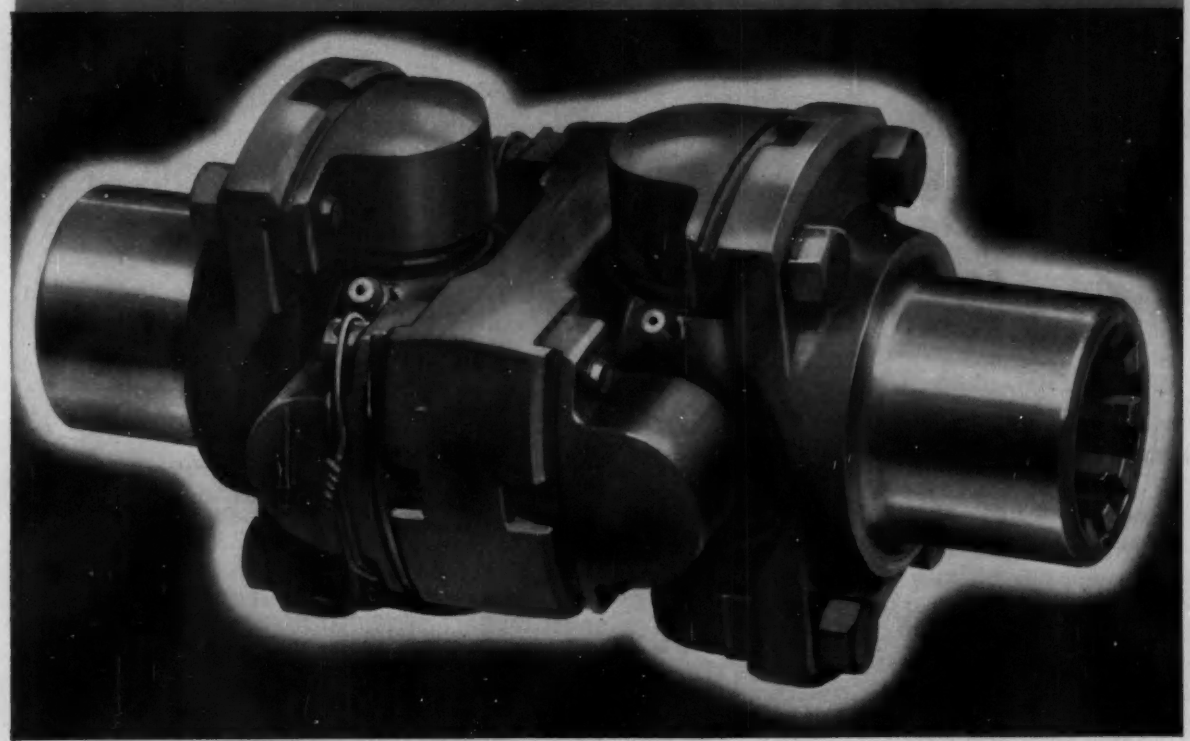

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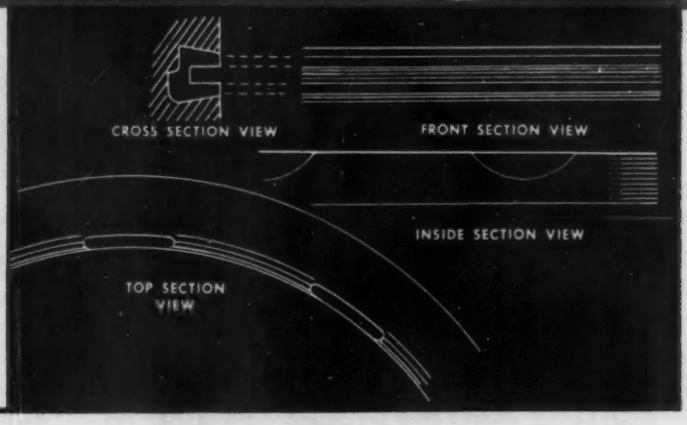

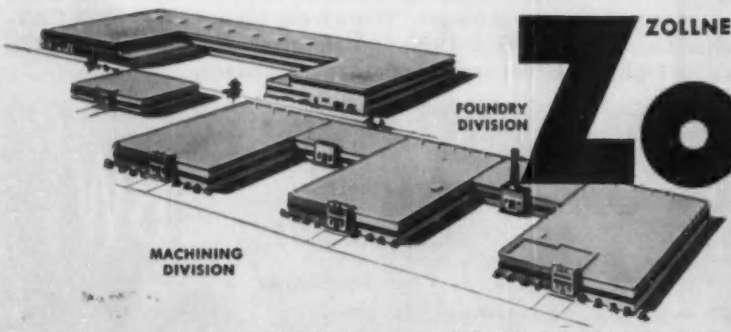

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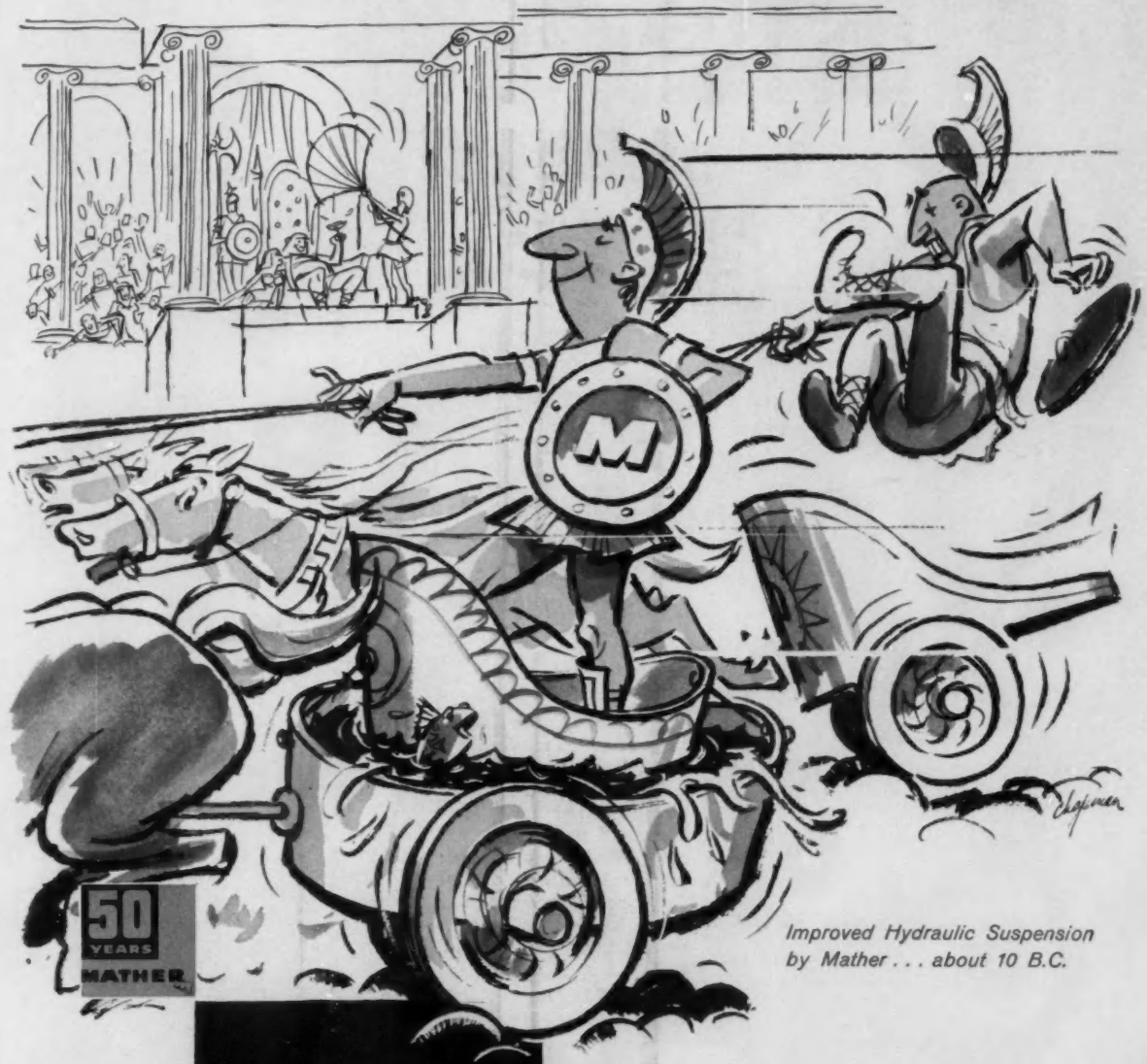

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